Identifying HI-Selected Galaxy Groups in the LADUMA Field

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Introduction:

The Looking At the Distant Universe with the MeerKAT Array (LADUMA; Blyth et al. 2016) survey represents a transformative effort to probe the neutral hydrogen (HI) content of galaxies across cosmic time, utilizing the exceptional sensitivity and resolution of the MeerKAT radio telescope. Targeting the extended Chandra Deep Field South (ECDFS), LADUMA provides a unique dataset to study galaxy evolution. This Master's project will focus on identifying and characterizing HI-selected galaxy groups in the LADUMA field using Data Release 1 (DR1), laying the groundwork for future studies investigating how group environments influence the HI properties of galaxies and offering insights into the physical processes that govern galaxy evolution.

Scientific Motivation:

The majority of galaxies in the Universe reside in groups (Eke et al. 2004), where environmental processes such as tidal interactions, and mergers play a pivotal role in shaping their evolution. Systematic studies of both compact (e.g., Verdes-Montenegro et al., 2001; Borthakur et al., 2015) and loose (e.g., Dénes et al., 2014; Maina et al., 2022) groups reveal that HI deficiencies or excesses are common in these environments, reflecting the interplay between galaxy interactions and gas dynamics. These interactions are known to affect the HI content of galaxies significantly, which could potentially lead to variations in HI scaling relations that connect HI mass to galaxy properties like size, optical magnitudes, colors, UV luminosity, and stellar mass. The LADUMA survey, with its deep HI observations in the redshift range $z < 0.1$ (specifically the 1304–1420 MHz frequency cube), offers an unprecedented opportunity to study these effects in a statistically significant sample of nearby galaxy groups (an example of such group is shown in Fig. 1). This project will focus on identifying HI-selected groups and crossmatching them with existing catalogs, laying the groundwork for a detailed analysis of environmental influences on HI properties.

Project Objectives:

This Master's project is designed to provide a focused investigation into galaxy groups within the LADUMA field, with the following key objectives:

- **Identify HI-selected galaxy groups**: Using the LADUMA DR1 source catalog, detect and characterize groups of HI-detected galaxies at $z < 0.1$, defined by a multiplicity $N_{FoF} > 3$ and linked via a friends-of-friends (FoF) algorithm.
- **Crossmatch with ancillary optical catalogs**: Compare the HI-selected groups with the ancillary optical spectroscopic catalog to assess completeness and reliability, providing insights into the diversity of group environments captured by HI observations.

- **Lay the foundation for scaling relation analysis**: Prepare a well-characterized group sample that can be used to explore how HI scaling relations (e.g., HI mass vs. size, optical properties, UV luminosity, stellar mass) vary with environment, identifying potential outliers for future study.

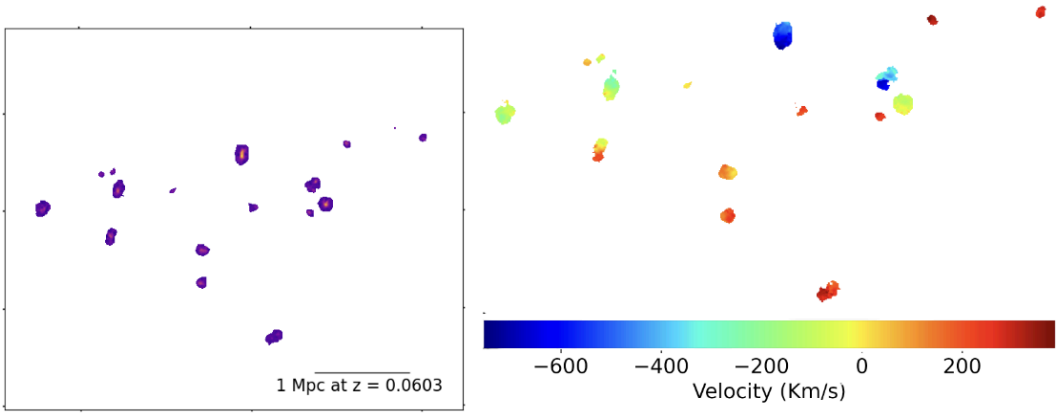

Figure 1: HI group with the most members (18) at z = 0.0603. Left: moment-0 HI map; Right: moment-1 velocity map relative to the group mean velocity.

Skills Gained:

- Hands-on experience with HI 21 cm spectral line data, including data handling, visualization, and analysis techniques in radio astronomy.
- Practical experience in galaxy group identification techniques with application of statistical and clustering algorithms in Python.
- Cross-matching multiwavelength astronomical datasets.
- Understanding of HI observations and their role in galaxy evolution studies.

Scientific Significance:

This project contributes directly to our understanding of galaxy evolution by providing a new HI-selected group sample within the LADUMA field. By identifying groups and crossmatching them with existing catalogs, the student will help establish a framework for studying how environmental processes regulate HI gas. The results will complement ongoing LADUMA efforts and recent findings (Mohapatra et al., 2025, accepted for publication in Proceedings IAU Symposium No. 392), which highlight the diversity of HI-rich groups and their potential to reveal environmental effects.

Who Should Apply?

We encourage NASSP honours students with an interest in galaxy evolution, extragalactic astronomy, and data analysis to apply. While prior experience with Python and astronomical

datasets is helpful, it is not required. This project is ideal for students looking to gain expertise in radio astronomy, HI 21 cm line analysis.

Contact Information: Please reach out to the supervisors for inquiries or to express interest in this project.