The Arecibo Legacy fast ALFA Survey: The January 2009 Undergraduate Workshop

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ABSTRACT

The 2009 Undergraduate Arecibo Legacy Fast ALFA (ALFALFA) Team Workshop will take place on January $12^{th}-14^{th}$, providing undergraduate students with research experience within the ALFALFA survey. ALFALFA is a blind, extragalactic, HI survey aiming to cover ∼7,000 deg^2 of high galactic latitude sky between 0° and +36° in declination and two blocks in right ascension of $07^h30^m-16^h30^m$ and $22^h00^m-03^h00^m$. The workshop observations will cover two drifts with right ascensions and declinations of $07^h00^m-14^h01^m$ and +03°39'00" (J2000), and $07^h04^m-14^h05^m$ and +03°24'24" (J2000), selected from the ALFALFA master drift list. The southern region of the Virgo Cluster, objects within the Leo Group, and High Velocity Clouds will be covered by the observations.

1. Introduction

Tracing HI content gives knowledge of galaxy structures, dynamic masses of galaxies, galaxy distances, galaxy-galaxy interaction within groups and clusters, and can be compared with star formation rates to probe galaxy evolution. The ALFALFA survey is a blind extragalactic HI survey aiming to cover ∼7,000 deg^2 of high galactic latitude sky out to a redshift of z ∼ 0.06, between 0° and +36° in declination and two blocks in right ascension of 07^h30^m to 16^h30^m and 22^h00^m to 03^h00^m. The total survey will require ∼4,000 hours of telescope time and is expected to detect 20,000 extragalactic HI line sources ranging from nearby

low mass dwarfs to massive spirals at z $\sim$ 0.06 (Giovanelli *et al.* 2005). Since ALFALFA is a blind survey, it will be unbiased to previously discovered or bright galaxies. Arecibo's large diameter greatly improves the sensitivity and resolution compared to previous HI surveys (such as HIPASS and HIJASS), enabling fewer follow-up synthesis observations needed to sufficiently map the HI structures.

The Virgo Cluster and its environment is a prime target for the project, due to the area of sky visible to the telescope. ALFALFA has already produced catalogs of the region. One catalog of the northern zone, declination range $+12^\circ$ to $+16^\circ$, presents 730 HI sources (Giovanelli *et al.* 2007). Another dataset in declination $+8^\circ$ to $+12^\circ$ reports 578 detections (Kent *et al.* 2008). The Cluster is ideal for studying galaxy-galaxy interactions and galaxy-intracluster medium interactions. Analysis of this high density region in comparison to lower density regions will enable the study of the evolution of galaxies in relation to their surroundings.

ALFALFA will address issues about the formation and evolutionary history of the extremely dispersed population of gas-rich dwarf galaxies. The data can be used to explore their relation to the missing satellite problem, an evident paradox seen between the number of low mass halos observed in the Local Group and that predicted by numerical simulations. Due to the survey's wide aerial coverage, sensitivity, and spectral resolution, these issues can be studied in such diverse regions as the Virgo Cluster and local voids (Haynes 2008).

The ALFALFA Undergraduate Workshop allows students and their faculty mentors the opportunity to operate the world's largest radio telescope. This is the fourth running workshop allowing two, 7-hour time slots of data collection. It will present research opportunities for the undergraduate students.

2. Observations and Data Reduction

Undergraduate students plan to make observations by means of existing ALFALFA techniques of two-pass strategy, minimum intrusion and fixed-azimuth drift mode (Giovanelli *et al.* 2005). These techniques minimize effects of the change in beam parameters while the telescope tracks by keeping the telescope at a fixed declination on the meridian as the Earth rotates. The two-pass strategy helps distinguish between outside noise and terrestrial interference.

The two observing sessions of the workshop will be carried out on January 12^{th} and 13^{th} between 00:00 and 07:00 AST. The drifts, selected from the ALFALFA master drift list, correspond to right ascension ranges of $07^h00^m-14^h01^m$ and $07^h04^m-14^h05^m$, centered at declinations of 03°39'00" (J2000) and 03°24'24" (J2000), respectively. Undergraduate students will be guided through the process of observation and data reduction by experienced graduate students. As part of the workshop activities, the students will then reduce the data using current ALFALFA software.

3. Focus of Observations

To complement ALFALFA research, we wish to focus our observations on the ALFALFA sky survey while aiding our understanding of galaxies. Our assigned drifts cover the extreme southern region of the Virgo Cluster, providing ample data for the analyses mentioned in the Introduction. The region is ideal for the search of galaxy-galaxy interactions in the form of tidal tails or detached HI clouds. A 500 kpc HI stream, located southwest of the Cluster and apparently associated with the galaxy pair NGC 4532/DDO 137, was discovered from ALFALFA data (Koopman *et al.* 2008). This feature is possibly the longest and outermost HI tail structure found on a cluster. The new data might identify similar or even more extreme structures.

Maps made from ALFALFA detections provide more precise identification of structures. One example is the HI map of the surroundings of the Virgo Cluster galaxy NGC 4254 (Haynes *et al.* 2007). It shows a long

complex of clouds extending northward from the galaxy to approximately 250 kpc and an object previously identified as a dark galaxy, Virgo HI21, as a condensation within these clouds. ALFALFA's superb sensitivity and resolution will provide data for additional, accurate maps of other features.

One area of interest includes the galaxies NGC 3169, NGC 3166 and NGC 3165 which form a group of spiral galaxies located in the constellation Sextans within the Leo II Group (See Figure 1). All three galaxies have similar redshifts of z = 0.004130, z = 0.004486 and z = 0.004470. There is a dramatic hydrogen distribution located around the three galaxies; most of the hydrogen seems to be linked with NGC 3169 (See Figure 2). The disturbed shapes of NGC 3169 and 3166 provide evidence of interaction between the galaxies. NGC 3169 shows an extended halo and an asymmetric arm and is classified as an Sa galaxy while NGC 3166 is classified as an S0/a (Haynes 1981). Our observations will aid us in better understanding the interaction between the galaxies through analysis of the HI structure surrounding these galaxies. It will also allow the discovery of faint, HI-rich dwarf members of the group.

ALFALFA sensitivity and coverage will significantly improve catalogs of HI High Velocity Clouds (HVCs) (Saintonge *et al.* 2008). HVCs are enigmatic structures that have absolute radial velocities incompatible with the galactic rotation model and, since they have no associated stars, direct distance measurements cannot be made. Some clouds are extended and form large complexes, while others are small and compact. ALFALFA's improved spatial and spectral resolution is an important advantage when studying the cores of the complexes and the compact HVCs (Giovanelli *et al.* 2005). Our drifts will cross a region of the sky that contains clouds with very high positive velocities, along with many small clouds and at least three medium sized complexes (Wakker & van Woerden 1997).

4. References Cited

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Figure 1: DSS image of NGC 3169, NGC 3166 and NGC 3165 from left to right.

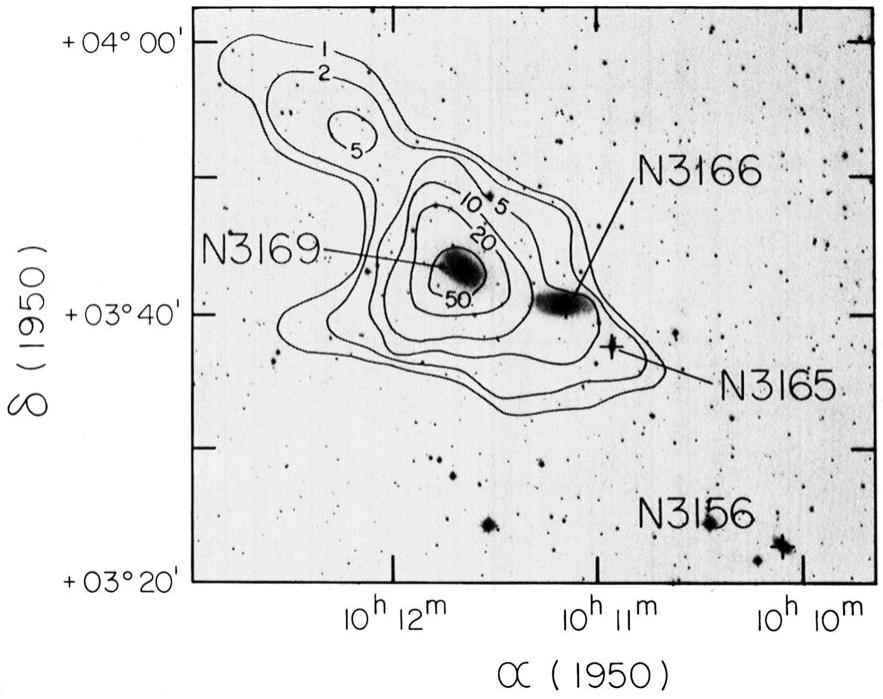

Figure 2: Hydrogen distribution surrounding NGC 3169, 3166 and 3165 was measured by Haynes (1981). The contours are in units of 10^{19} cm^{-2}.