ALFALFA: The Arecibo Legacy Fast ALFA Survey
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Abstract

The Arecibo Legacy Fast ALFA (ALFALFA) survey is a blind HI survey that will cover 7000 deg^2 of the sky and detect some 16000 extragalactic HI sources. The survey will contribute to the faint end of the HI mass function and help provide a multi-wavelength image of the sky. It will also help in the understanding of galaxy evolution within different environments. As part of the ALFALFA survey we propose to observe a region including the southern extension of the Virgo cluster, the nearest rich cluster. We predict detections of at least six sources of HI in the southern extension. At the distance of the Virgo cluster we expect to detect galaxies with HI masses as low as 10^7 $M_\odot$ (Giovanelli et al. 2005). With our observations of the HI structure of these objects, we will be able to construct a better model of past galaxian interactions in the southern extension of the Virgo cluster.

Introduction

HI content is an important indicator of future star formation in galaxies and a tracer of recent changes in galaxy gas distribution, caused by galaxy-galaxy interactions. The ALFALFA (Arecibo Legacy Fast ALFA) survey is a blind extragalactic HI survey that will map a large area of the sky at wavelengths suitable for the detection of neutral hydrogen (HI). It will cover an area of 7,000 deg^2 out to a redshift of z $\sim$ 0.06, between 0 and 36 degrees in declination and from 07h30m to 16h30m and 22h00m to 03h00m in right ascension (Giovanelli et al. 2005). Ultimately the results will be combined with sky surveys at other wavelengths to provide a multi-wavelength picture of the local universe. As a blind survey, this survey is unbiased towards bright and previously detected galaxies. It is estimated to detect 16000 extragalactic HI sources, providing HI redshifts, masses and rotational widths. As opposed to previous large HI surveys (such as HIPASS and HIJASS), the larger Arecibo diameter provides significant improvement in sensitivity and resolution, and therefore fewer followup synthesis observations will be necessary to adequately map the HI structures.

ALFALFA will also attempt to solve several astrophysical problems such as the missing satellite problem, which is the contradiction between the number of low mass halos observed and predicted in the local universe

(Kauffman et al. 1993; Klypin et al. 1999). Numerical simulations based on the cold dark matter (CDM) theory predict a higher number of dwarf dark matter halos than the observed population of dwarf satellite galaxies in the Local Group (Kauffman et al. 1993; Klypin et al. 1999). Current efforts are being focused on determining the faint end of the HI Mass Function (HIMF), which is difficult to measure directly, and an unbiased survey such as ALFALFA will help probe the fainter and lower mass end of the HIMF.

Furthermore, ALFALFA will explore galaxy evolution and dynamics within local large scale structures. At a distance of 50 million light years, the Virgo Cluster is the nearest rich cluster to our galaxy, with about 2000 known objects (Binggeli et al. 1985) and a perfect target of galaxy-galaxy interaction studies. Comparing HI and other properties of galaxies in high and low density regions will give us clues on the processes of environmental influence on galaxy evolution.

The ALFALFA survey is already helping make new discoveries in the Virgo cluster. The Virgo cluster's proximity and density make it an ideal environment to study. Currently, eleven previously detected galaxies with unknown redshifts have been detected in the survey and there have been multiple detections that do not have any visible counterparts. A new extended source has been detected that may be a high velocity cloud or a remnant of galaxy harassment (Kent 2006). Our proposed region of observation will nicely fit in with the current data on the Virgo cluster, being a few degrees south of the current extent of the observations.

Observations and Data Reduction

The observations are scheduled for July 12th, between 1700 and 1830 AST, which corresponds to a right ascension range of 11h55m to 13h25m; our declination, chosen from the ALFALFA master drift list, is +03 53 36 (J2000). Observations will take place during the 2006 ALFALFA Undergraduate Workshop. Experienced graduate students will guide the 15 undergraduates attending the workshop though the process of remote observing and data reduction. Current ALFALFA software will be used for data reduction and thus the same observing techniques will be implemented throughout the process. The data reduction will take place on the following day during the workshop.

The observations will be taken in fixed-Azimuth Drift Mode, where the telescope is pointed at one declination and the sky drifts by. An advantage to this is the minimum intrusion principle (Giovanelli et al. 2005). By keeping the beam fixed, the beam pattern is more easily removed and the data are more easily reduced and of superior quality.

Focus of Observations

To pursue our own scientific interests while covering a region of the sky that is targeted by ALFALFA, we were limited to declinations in the master drift list for observation. Our chosen declination of +03 53 36 (J2000) in the RA range from 11h55m to 13h25m covers the southern extension of the Virgo cluster. A number of sources in this region have not yet been classified as being Virgo cluster members or background galaxies; our observations could help with the classification of these sources. The galaxies we expect to observe, that is, those with a redshift of $z < 0.06$ and an HI signal well above 3.5 mJy include UGC 7354, UGC 7983, UGC 8055, UGC 8186, CGCG 041-036, NGC 4412, NGC 4496A, NGC 4496B and NGC 4630.

The choice of this region is a result of many factors. This drift was previously observed starting at LST 13h19 on 06.05.16, so our observations will complement existing ALFALFA data quite well. The observations of detectable galaxies will yield a second measurement of these galaxies, including an estimate of their HI masses and further understanding of the HI absorption feature. By completing the drift we can begin searching for interesting HI structure. With the improved resolution of the ALFA beam compared to previous large HI surveys, we should be able to see these structures in some detail.

For example, the spectrum of NGC 4412 in the region shows a double-horn HI profile wherein one of the horns has been depleted of HI (Figure 1). Possibly this is due to ram pressure stripping (Hoffman et al. 1985). Our observation of this object should clarify its HI structure and give insight into its past. Two other

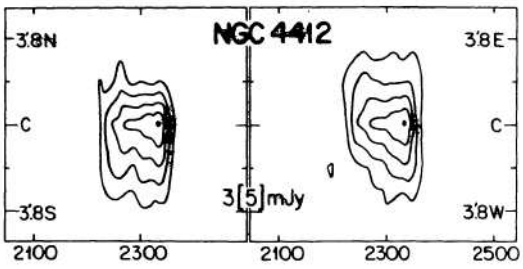

Figure 1: The HI profile of NGC 4412 was measured by Hoffman et al (1989). The asymmetrical structure of NGC 4412 is a common feature of Virgo Cluster galaxies.

galaxies of interest are NGC 4496A and NGC 4496B. The centers of these two galaxies have an angular separation of 0.9' (Figure 2). The image of NGC 4496A overlaps NGC 4496B and these were initially believed to be interacting galaxies, but more recent redshift measurements indicate that NGC 4496B is far in the background (e.g., Sloan Digital Sky Survey).

Galaxies are expected to fall into clusters along filaments, perhaps experiencing preprocessing of their gaseous and stellar contents (Boselli and Gavazzi 2006). Thus we may see remnants of galaxy-galaxy interaction in the form of tidal tails or detached HI clouds in the southern extension of the drift. The high sensitivity of the survey will detect previously unknown features if they exist. In keeping with the goals of the ALFALFA survey, the rest of the drift will focus on the detection of new galaxies and HI, while the subset of the observations that includes the southern extension will enhance our understanding of galaxy dynamics and evolution within groups.

Summary of Technical Requirements

We require an hour and thirty minutes of time, using ALFA as a receiver, spaced between an LST range of 11h55m and 13h25m to cover the southern extension of the Virgo Cluster. The Wideband Arecibo Pulsar Processor system will be centered at 1385 MHz to give us a range from 1335 to 1435 MHz. This will cover a velocity range from -2000 to 18,000 km/s. Spectra will be recorded once a second in 600s drifts, between which a noise diode will be fired for calibration. We will use a fixed-azimuth drift scan technique during the observations.

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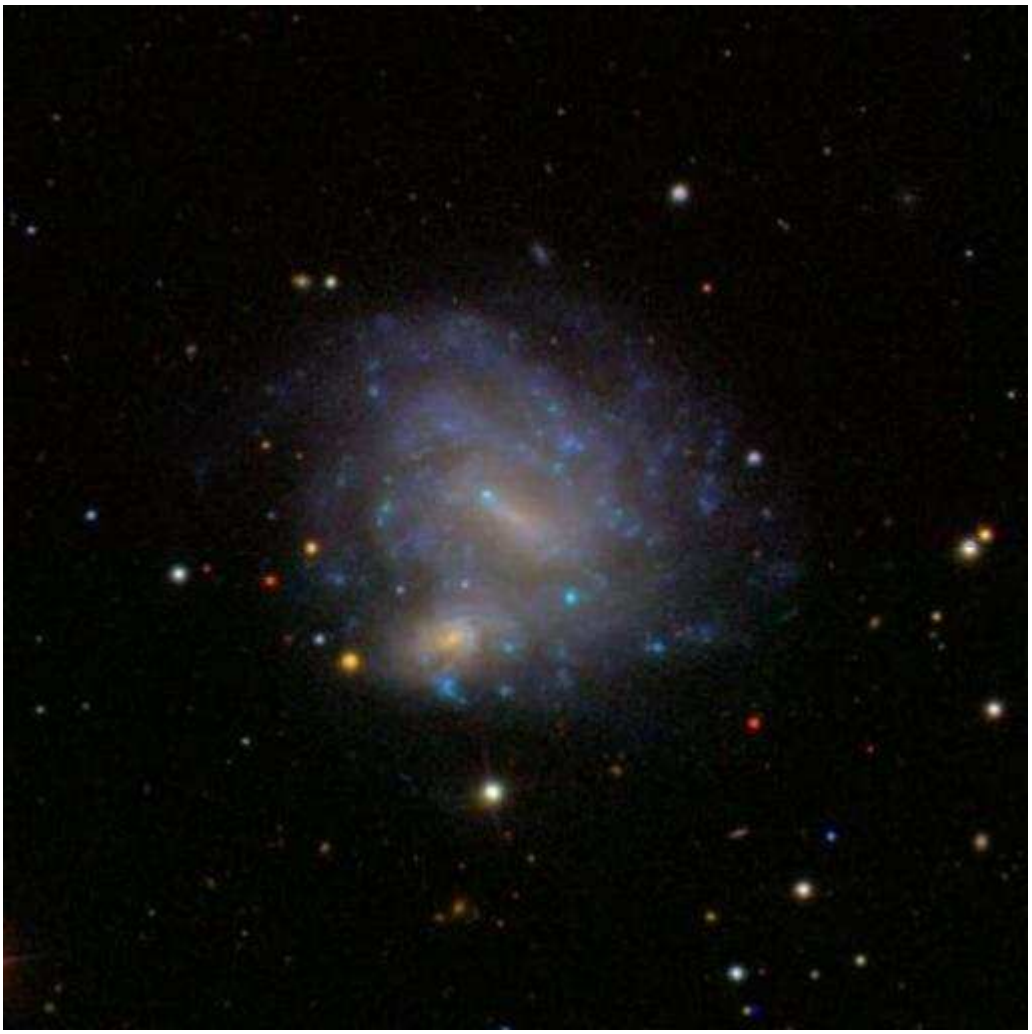

Figure 2: SDSS image of the angularly close NGC 4496A and NGC 4496B galaxies. Redshift measurements indicate that NGC 4496B is far in the background.