

ALFALFA Discovery of an HI Cloud Complex in the Virgo Cluster

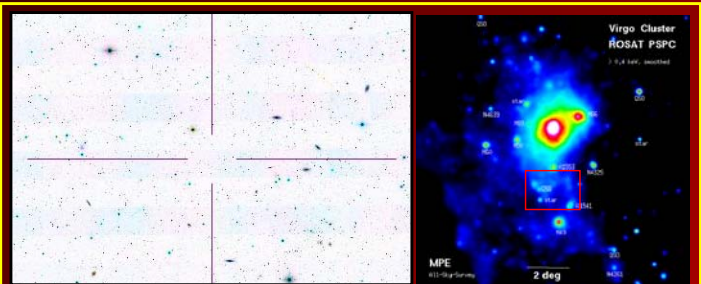
R. Giovanelli, M.P. Haynes, B. Kent, A. Saintonge, S. Stierwalt (Cornell U.), N. Brosch (Tel Aviv U.), L. Hoffman (Lafayette Coll.), J. Rosenberg (CfA), B. Catinella and E. Momjian (Arecibo Obs.)



Abstract: A large complex of HI clouds was discovered in the course of the Spring 2005 observations of the ALFALFA survey (Giovanelli et al. 2005, AJ 130:2598) at the Arecibo 305 m telescope. The complex extends about 40'' at a mean heliocentric radial velocity of 500 km/s. It consists of several clumps, the largest of which is centered near 12:30:26+09:28:00 (2000). The overall HI mass of the system approaches 10⁹ solar, if a distance of 16 Mpc is assumed. No ordered velocity field is discernible. Most of the components of the system do not appear to be associated with optical counterparts, except for a cloud near 12:31:18+09:29:00, cz=606 km/s, which appears to be related with the galaxy VCC1357, a dl(?) of 0.2x0.1 arcmin. The galaxy NGC 4424, an SBA of 3.6x1.8 arcmin at cz=476 km/s, is located some 45'' (210 kpc at the cluster distance) away from the center of the cloud complex and it exhibits a disturbed HI disk (Cortés, Kenney and Hardy 2005, preprint). Morphology and velocity fields do not suggest a tidal origin for the system. Interpretation in terms of a galaxy harassment scenario in the cluster potential appears more likely. Structural details of the central region of the complex are shown in the VLA HI synthesis images presented in the companion paper by Spekkens et al. (2006). This research is partially supported by NSF/AST 0307661 NSF/AST-0435697 and a Brinson Foundation grant.

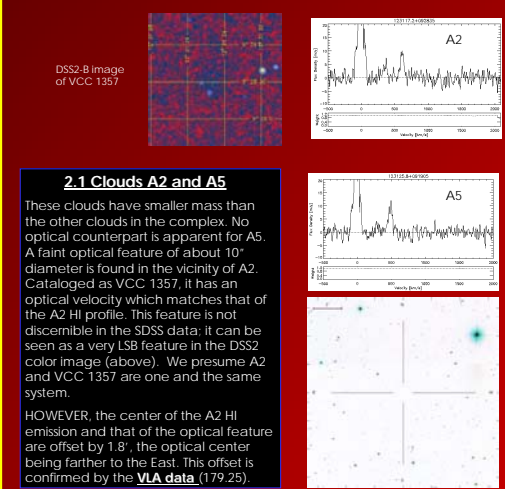
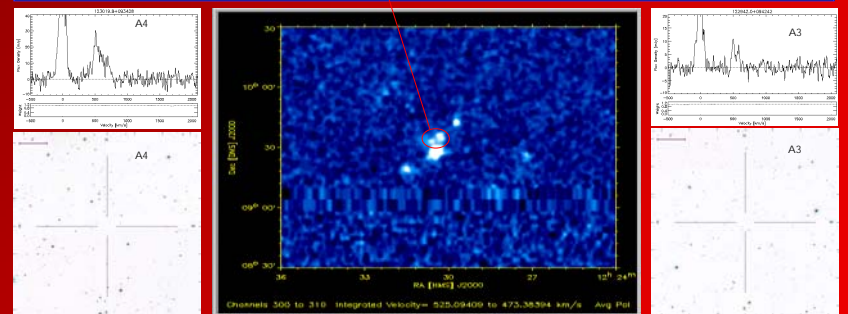
What is ALFALFA?

- The **Arecibo Legacy Fast ALFA** survey aims to map 7000 square degrees of the high galactic latitude sky in the 21 cm line of HI.
- It uses the ALFA seven-feed array at the Arecibo Observatory. The spectral coverage is -2000 to +18000 km/s in cz, with a resolution of 5 km/s.
- The sky is mapped in drift mode, with two passes on each sky section, yielding better than full Nyquist sampling. Average rms is 2 mJy per beam.
- Completion of the survey will require 4400 hours of telescope time, spread over ~5 hours of calendar time. Observations started in February 2005.
- Preliminary results of the survey are presented in the companion posters by **Haynes et al.** (179.23), **Saintonge et al.** (187.02), **Kent et al.** (179.20), **Stierwalt et al.** (187.03), **Spekkens et al.** (179.25), **Koopmann et al.** (179.23), **Avaya et al.** (179.21) and in the oral presentations by **Giovanelli** (192.03) and **Haynes** (192.03).
- **ALFALFA** is an open collaboration, currently including 52 investigators from 34 institutions in 13 countries. Simple guidelines for participation in the survey or in follow-up activities can be found in the survey website (<http://egg.astro.cornell.edu/alfalfa>).



1. HI data of a 3x2 degree region in the Virgo cluster are discussed. The region is located between the M87 and M49 concentrations, as shown by the box superimposed on the ROSAT X-ray emission map. The image to the left is from SDSS, extending between 12^h 24^m and 12^h 36^m, +8° 30' and +10° 30'. In this poster, we present results from the ALFALFA survey at Arecibo; in a companion poster by Spekkens et al. results of follow-up observations with the **Very Large Array** are shown.

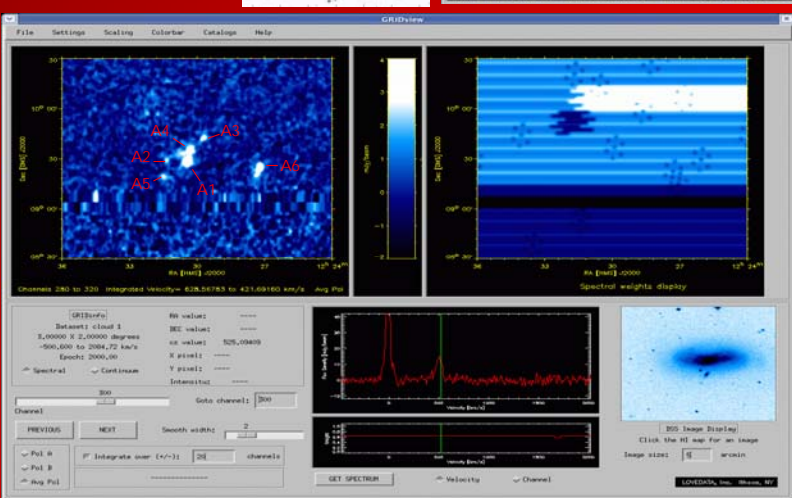
2.2 Clouds A3 and A4: Cloud A3, farthest to the North in the complex, is unresolved by the Arecibo beam. The 2-horned appearance of the HI profile, typical of rotating disks, may be a result of poor signal-to-noise. Cloud A4 is resolved by the beam and it has a relatively broad velocity width, suggestive of a large mass and perhaps ordered rotation. However, close inspection of channel maps indicates that A4 is a collection of smaller clumps, as shown in the image below, integrated between 473 and 525 km/s, and no ordered velocity field can be inferred.



2.1 Clouds A2 and A5

These clouds have smaller mass than the other clouds in the complex. No optical counterpart is apparent for A5. A faint optical feature of about 10'' diameter is found in the vicinity of A2. Cataloged as VCC 1357, it has an optical velocity which matches that of the A2 HI profile. This feature is not discernible in the SDSS data; it can be seen as a very LSB feature in the DSS2 color image (above). We presume A2 and VCC 1357 are one and the same system.

HOWEVER, the center of the A2 HI emission and that of the optical feature are offset by 1.8'', the optical center being farther to the East. This offset is confirmed by the **VLA data** (179.25).



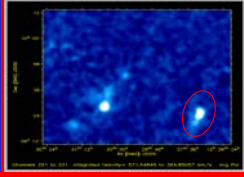
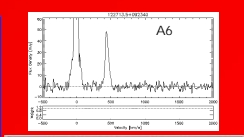
2.4 Cloud A1 At the center of the cloud complex, A1 is also detected by the VLA, which it shows to extend about 2.5'' (see poster 179.25). No cataloged galaxies lie near the HI, although a tiny diffuse feature appears near its center (see image to the left). Using the HI size and the ALFALFA spectrum, a virial mass of 2x10⁹ solar can be obtained, which exceeds the HI and stellar (if any) mass by an order of magnitude.

2. ALFALFA Data

The central panel displays, on the upper left, an HI map integrated between 421 and 628 km/s. The flux scale is indicated by the sidebar plot; the rms noise in the map is ~0.5 mJy/beam. The map on the right illustrates the degree of completion of the ALFALFA survey in this region; the parts of the map in white have been covered 3 times by the ALFA beams, those in light blue twice, those in dark blue once and those in black not covered yet. The hexagonal dot features in the map identify 1'' gaps in data taking, between one scan and the next.

Six HI features are labeled in the map. Two of them (A1 and A2) are also clearly detected by the **VLA** (see poster 179.25). The integrated HI profiles and optical images of the 6 fields are discussed in the captions 2.1 to 2.4. A6 is the galaxy N4424, an SDSS image of which is shown at bottom right. An HI profile corresponding to the center of the feature A3 is shown in red at the center of the panel.

ALFALFA data processing takes place in an interactive environment with built-in access to NVO, NED and other web-based resources.



3. Cloud Parameters

Cloud	Cat Names	Coords (2000)	Flux Int Jy/km/s	Vhel km/s	Width km/s	HI mass 10 ⁹ solar
A6	7561 N4424	122710.4+092450	2.75	441	58	1.66
A3		122942.0+094242	0.88	535	123	0.53
A4		123019.9+093428	3.31	599	247	2.00
A1		123025.5+092755	2.59	491	60	1.56
A2	220725 vcc1357	123117.2+092835	0.64	609	58	0.39
A5		123125.8+091905	0.79	485	59	0.48

4. So, What is it?

- The total HI mass of clouds A1-5 adds up to 5x10⁹ solar. There appears to be diffuse, low SB emission distributed over a large solid angle, which is not accounted for by the sum of the cloud masses, so the total HI mass of the system may well be near 10⁹ solar. This exceeds the HI mass of any galaxy within several hundred kpc projected distance and cz < 1000 km/s.
- The topology is characterized by clumpiness on all scales and the kinematics by lack of ordered motions.
- The complex does not appear materially connected to any massive galaxy in the field. Combined with the characteristics of the velocity field, this makes a 2-galaxy tidal interaction improbable. However, the gas in NGC4424 (at a projected distance of ~220 kpc) exhibits clear evidence of major disruption.
- One and possibly two of the clouds in the complex appear to have very minimal optical counterparts. In the clearer of those cases (A2), the HI and the stars are offset by some 7 kpc from each other.
- The system has many characteristics in common with others found in the Virgo cluster, namely those near NGC4254 (see poster by Haynes et al.), NGC 4192 (recently found by ALFALFA, work in preparation), and NGC 4388 (Osterloo and van Gorkom 2005).
- The most likely interpretation of the observations is that the cloud complex consists in the fossil remnants of a galaxy harassment episode, whereby most of the gas of a large disk galaxy (or of a group) has been torn apart by the gravitational action of the cluster potential.

Visit the **ALFALFA website at:**
<http://egg.astro.cornell.edu/alfalfa>