Dark Galaxies and Lost Baryons
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ALFALFA: HI Cosmology in the Local Universe

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Abstract. For the last 25 years, the 21 cm line has been used productively to investigate the large–scale structure of the Universe, its peculiar velocity field and the measurement of cosmic parameters. In February 2005 a blind HI survey that will cover 7074 square degrees of the high latitude sky was started at Arecibo, using the 7-beam feed L-band feed array (ALFA). Known as the Arecibo Legacy Fast ALFA (ALFALFA) Survey, the program is producing a census of HI-bearing objects over a cosmologically significant volume of the local Universe. With respect to previous blind HI surveys, ALFALFA offers an improvement of about one order of magnitude in sensitivity, 4 times the angular resolution, 3 times the spectral resolution, and 1.6 times the total bandwidth of HIPASS. ALFALFA can detect $7 \times 10^4 D^2$ $M_\odot$ of HI, where D is the source distance in Mpc. As of mid 2007, 44% of the survey observations and 15% of the source extraction are completed. We discuss the status of the survey and present a few preliminary results, in particular with reference to the proposed "dark galaxy" VirgoHI21.

Keywords. galaxies: distances and redshifts, galaxies: dwarf, galaxies: evolution, galaxies: formation, galaxies: mass function, galaxies: spiral, cosmology: cosmological parameters, cosmology: observations, cosmology: large-scale structure of universe, radio lines: galaxies

1. What is ALFALFA?

Comprehensive wide angle surveys of the extragalactic HI sky became possible with the advent of multifeed front–end systems at L–band. The first such system with spectroscopic capability was installed on the 64 m Parkes telescope in Australia, and has produced the excellent results of the HIPASS survey (Barnes *et al.* 2001). The 1990s upgrade of the Arecibo telescope, which replaced its line feeds with a Gregorian subreflector system, made it possible for that telescope to host feed arrays, as proposed by Kildal *et al.* (1993). Eventually a 7-beam radio "camera", named ALFA (Arecibo L–band Feed Array), became operational at Arecibo, enabling large–scale mapping projects with the great sensitivity of the 305–m telescope. A diverse set of mapping projects are now underway at that observatory, ranging from extragalactic HI line, to Galactic line and continuum, to pulsar searches. ALFALFA, the Arecibo Legacy Fast ALFA Survey, aims to map the peri– and extragalactic HI emission over 7074 deg^2 of the high galactic latitude sky. This will require a total of 4130 hours of telescope time. Exploiting the large collecting area of the Arecibo antenna and its relatively small beam size ($\sim$3.5′), ALFALFA will be eight times more sensitive than HIPASS with $\sim$four times better angular resolution. The combination of sensitivity and angular resolution allows dramatically improved ability in determining the position of HI sources, a detail of paramount importance in the identification of source counterparts at other wavelengths. Furthermore, its spectral backend provides 3 times better spectral resolution (5.3 km s^{-1} at $z = 0$) and over 1.4 times more bandwidth. These advantages, in combination with a simple observing technique designed to yield excellent baseline characteristics, flux calibration and HI signal verification, offer new opportunities to explore the extragalactic HI sky. A comparison of ALFALFA and other past and current HI surveys is given in Table 1. Data taking for ALFALFA was initiated in February 2005, and, in the practical context of time allocation at a widely used, multidisciplinary national facility like Arecibo, completion of the full survey is projected to require 6 years.

The main science goals to be addressed by ALFALFA are:

• The determination and environmental variance of the HI mass function, especially at its faint end and its impact on the abundance of low mass halos

• The global properties of HI selected galaxy samples

• The large–scale structure characteristics of HI sources, their impact on the "void problem" and metallicity issues

• Provide a blind survey for HI tidal remnants and "cold accretion"

• A direct characterization of the HI Diameter function

• Investigate the low HI column density environment of disks

• Map and help elucidate the nature of HVCs around the Milky Way (and beyond?)

• The ALFALFA survey area includes ∼2000 continuum sources with fluxes sufficiently large to make useful measurements of HI optical depth for DLA absorbers at low z

• ALFALFA will double the number of known OH Megamasers at intermediate redshifts

The choice of survey parameters for ALFALFA is summarily justified by the following consideration. The minimum integration time per beam in seconds t_s necessary for ALFA to detect an HI source of HI mass M_{HI}, width W_{kms}, at a distance D_{Mpc} is

$$t_s \simeq 0.25\Big(\frac{M_{HI}}{10^6 M_\odot}\Big)^{-2}(D_{Mpc})^4\Big(\frac{W_{kms}}{100}\Big)^{\gamma}, \tag{1.1}$$

where the exponent $\gamma \simeq 1$ for $W_{kms} < 300$ km s^{-1}and increases to $\gamma \simeq 2$ for sources of larger width. This means that the depth of the survey, i.e. the maximum distance at which a given HI mass can be detected, increases only as $t_s^{1/4}$: longer integrations than strictly necessary to achieve scientific goals lead to rapidly diminishing returns. A corollary of this scaling law is the fact that, once M_{HI} is detectable at an astrophysically satisfactory distance, it is more advantageous to maximize the survey solid angle than to increase the depth of the survey through longer dwell times. In passing, we note that the t_s required to detect a given M_{HI} at a given distance decreases as the 4th power of the telescope diameter: Arecibo offers a tremendous advantage because of its huge primary reflector. A drift survey has many important advantages, especially at a telescope with properties which vary across the (AZ,ZA) space, such as the Arecibo dish. A double–drift survey offers all–important additional advantages in terms of RFI excision. The effective integration time per beam area of a double–drift survey with ALFA is of order of 40 sec. This translates to a minimum detectable HI mass of 2×10^7 $M_\odot$ at the distance of the Virgo cluster and in a catalog of sources with a median $cz \sim 7800$ km s^{-1}.

The sky coverage of ALFALFA includes the region from 0° to +36° in declination and from 22^h <R.A.< 3^h (the "fall sky") and 7^h30^m <R.A.< 16^h30^m (the "spring sky"), as illustrated in Figure 1. Observations are carried out in drift mode, and each region of the sky is visited at two different epochs, separated by a few months of Earth's orbital phase. No "tracking L.O." is applied to data taking. This fixed azimuth, "minimum intrusion" observing technique delivers high data quality and extremely high observing efficiency. Because of its wide areal coverage and photometric accuracy, ALFALFA is providing a legacy dataset for the astronomical community at large, serving as the basis for numerous studies of the local extragalactic Universe. As of mid–2007, 44% of the survey solid angle has been fully mapped. Further details on the design and progress of

Table 1. Comparison of Blind HI Surveys

Survey	Beam (′)	Area (deg^2)	res (km s^{-1})	rms^a	V_{med} (km s^{-1})	N_{det}	Ref
AHISS	3.3	13	16	0.7	4800	65	^{b}
ADBS	3.3	430	34	3.3	3300	265	^{c}
WSRT	49.	1800	17	18	4000	155	^{d}
HIPASS	15.	30000	18	13	2800	5000	^{e,f}
HI-ZOA	15.	1840	18	13	2800	110	^{g}
HIDEEP	15.	32	18	3.2	5000	129	^{h}
HIJASS	12.	1115	18	13	^{i}	222	^{i}
J-Virgo	12.	32	18	4	1900	31	^{j}
AGES	3.5	200	11	0.7	12000		^{k}
ALFALFA	3.5	7074	11	1.7	7800	>25000	^{l}

[a]mJy per beam at 18 km s^{-1} resolution; [b]Zwaan *et al.* (1997, *ApJ* 490, 173); [c]Rosenberg & Schneider (2000, *ApJSS* 130, 177); [d]Braun *et al.* (2003, *AAp* 406, 829); [e]Meyer *et al.* (2004, *MNRAS* 350, 1195); [f]Wong *et al.* (2006, *MNRAS* 371, 1855); [g]Henning *et al.* (2000, *AJ* 119, 2696); [h]Minchin *et al.* (2003, *MNRAS* 346, 787); [i]Lang *et al.* (2003, *MNRAS* 342, 738), HIJASS has a gap in velocity coverage between 4500-7500 km s^{-1}, caused by RFI; [j]Davies *et al.* (2004, *MNRAS* 349, 922); [k]Minchin *et al.* (2007, *IAU 233*, 227); [l]Giovanelli *et al.* (2007, *AJ* 133, 2569).

the survey can be seen in Giovanelli *et al.* (2005a), the presentation by Martin in these proceedings and at the URL *http://egg.astro.cornell.edu/alfalfa*.

ALFALFA is an open collaboration. Anybody with a legitimate scientific interest and willing to participate in the development of the survey can join. As of mid 2007, 68 individuals are participating in the ALFALFA observations, processing or follow–up activities. Follow–up activities include: HI synthesis and single dish high sensitivity observations; radio observations at other wavelength bands than HI; optical imaging in broad band and H_α and for distance determination; optical spectroscopy for redshift confirmation, H_α rotation curve mapping and metallicity determination; infrared and UV imaging. Access to cataloged survey products can be obtained at *http://arecibo.tc.cornell.edu/hiarchive/alfalfa* and survey progress, guidelines for joining and other details can be obtained at *http://egg.astro.cornell.edu/alfalfa*.

Data processing of ALFALFA and signal extraction (Saintonge 2007) takes place through IDL applications developed at Cornell University, fully embedded in the Virtual Observatory (VO) environment. Cross–referencing of HI data with source catalogs and images obtained at other wavelengths is enabled through all stages of data processing. ALFALFA products can be accessed through VO–compatible software tools: partial source catalogs are placed on the public domain as the survey progresses. Precursor ALFA data (Giovanelli *et al.* 2005b), previous archival pointed HI observations by the Cornell group for 9000 galaxies (this is already the largest collection of digital HI galaxy spectra in existence in the world) and the first ALFALFA catalog release (Giovanelli *et al.* 2007) are available through a node of the Virtual Observatory at the Cornell Theory Center (see *http://arecibo.tc.cornell.edu/hiarchive*). Team members have web access to preliminary, searchable source catalogs for the planning and execution of multiwavelength followup observations. These SQL searchable databases and plotting tools are made public as their associated presentation papers are accepted for publication, as per VO requirement. The data reduction, signal extraction and ancillary software has been exported to 15 sites

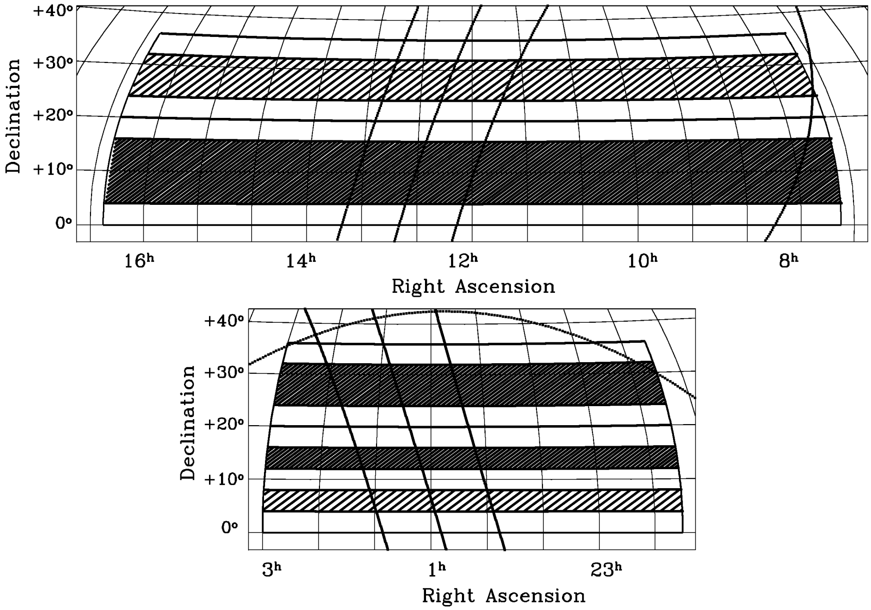

Figure 1. Sky coverage of the ALFALFA survey, in the Virgo or Spring (upper) and anti-Virgo or Fall (lower) regions. In each panel, the thicker lines at constant RA or Dec. outline the boundaries of the survey area. The thick curves to the right of the upper panel and top of the bottom panel mark b = $+20°$ (upper) and $-20°$ (lower) while the set of three thick lines crossing each panel top to bottom trace SGL = $-10°$, $0°$ and $+10°$. The regions in heavy shading correspond to parts of the sky fully mapped by mid–2007, while light shading masks the regions with started, but incomplete observations.

where it is in regular use by team members. Well-developed documentation and hands-on training in observation and reduction techniques are provided to new members by ALFALFA experts at Cornell, to ensure commonality of standards.

2. First Catalog Releases

Two catalogs of HI sources extracted from 3-D spectral data cubes have been submitted for publication in the first half of 2007, the first (Giovanelli *et al.* 2007) for the Spring sky, the second (Saintonge *et al.* 2007) for the Fall sky. In the first catalog, now in the public domain, 730 HI detections are cataloged and optical counterparts assigned, within the solid angle 11^h44^m < R.A. (J2000) < 14^h00^m and $+12°$ < Dec. (J2000) < $+16°$ (which includes the northern part of the Virgo cluster), and redshift range -1600 km s^{-1} < cz < $+18000$ km s^{-1}. In comparison, the HI Parkes All-Sky Survey (HIPASS) detected 40 HI sources in the same region, 2 of which are unconfirmed by ALFALFA. ALFALFA HI detections are reported for three distinct classes of signals: (a) detections with signal-to-noise ratio S/N > 6.5; (b) high velocity clouds in the Milky Way or its periphery; and (c) signals of lower S/N (to ∼4.5) which coincide spatially with an optical object of known, matching redshift.

Although this region of the sky has been heavily surveyed by previous targeted observations based on optical flux– or size– limited samples, 69% of the extracted sources are newly reported HI detections, an indication of the fact that our collective criteria

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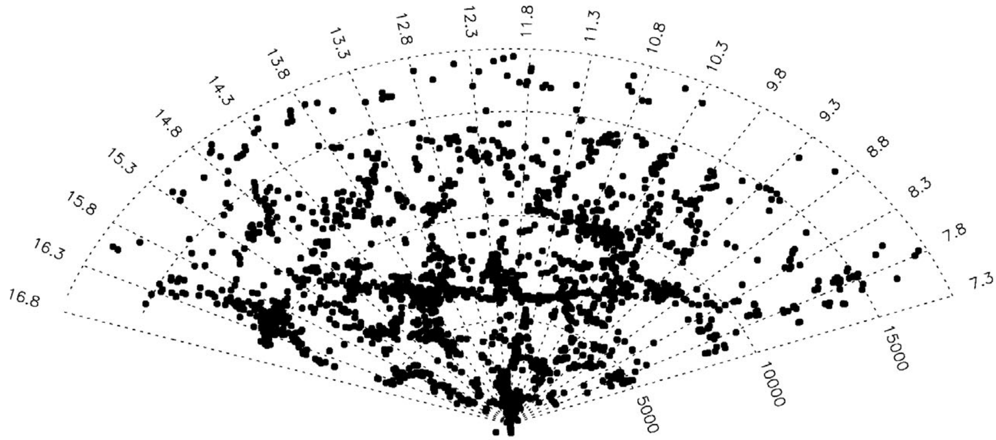

Figure 2. Wedge plot of 2657 HI sources detected by ALFALFA in the region R.A. = $[7.5^h–16.5^h]$, Dec = $[12°–16°]$, which represents 7.5% of the survey. Note that due to RFI, ALFALFA is effectively blind in the redshift range between approximately 15000 and 16000 km s^{-1}.

for selecting potentially HI–rich targets have neglected most of the HI-rich population of objects.

Signal extraction from ALFALFA data has been completed for some 15% of the survey area, as of mid–2007 and catalogs are in preparation for publication for submission in the second half of 2007. The largest contiguous region fully processed to date corresponds to a strip between 7.5^h and 16.5^h in R.A., 12° to 16° in Dec. A total of 2657 HI sources have been detected in that region, amounting to about 7.5% of the survey total solid angle. The detection areal density of about 5 sources per sq. deg. suggests that the full survey "catch" may eventually add to close to 30,000 HI sources, somewhat higher a number than estimated from survey simulations. Figure 2 shows a wedge diagram of the strip data set, neatly outlining the characteristics of the local Universe' s large scale structure. Note that, due to the impact of local RFI, ALFALFA is effectively blind in the redshift range cz ∼15000 to 16000 km s^{-1}.

3. Statistical Characteristics of the Survey

Figure 3 shows a HI mass vs. distance diagram of the HI sources in Figure 2. Two smooth lines are overplotted, identifying respectively the completeness limit (dotted) and the detection limit (dashed) for sources of 200 km s^{-1} linewidth for the HIPASS survey. This diagram dramatically illustrates the improvement ALFALFA represents, over previous surveys. The median redshift of the catalog is ∼7800 km s^{-1} and its distribution reflects the known local large scale structure. See Haynes' presentation in these proceedings for a discussion of the impact of these observations on the faint end of the HI mass function.

For the same set of sources, top panel on the right of Figure 3 displays S/N vs. velocity width, while the bottom panel displays the flux integral vs. velocity width. The quality of the ALFALFA signal extraction is apparent: the S/N of detections exhibits no significant bias with respect to velocity width. Spectroscopic HI surveys are not single flux limited. The flux limit is expected to rise as $W^{1/2}$ for low velocity widths, changing to a linear rise for the wider line profiles. Such a transition is observed near $\log W \simeq 2.5$. The ALFALFA

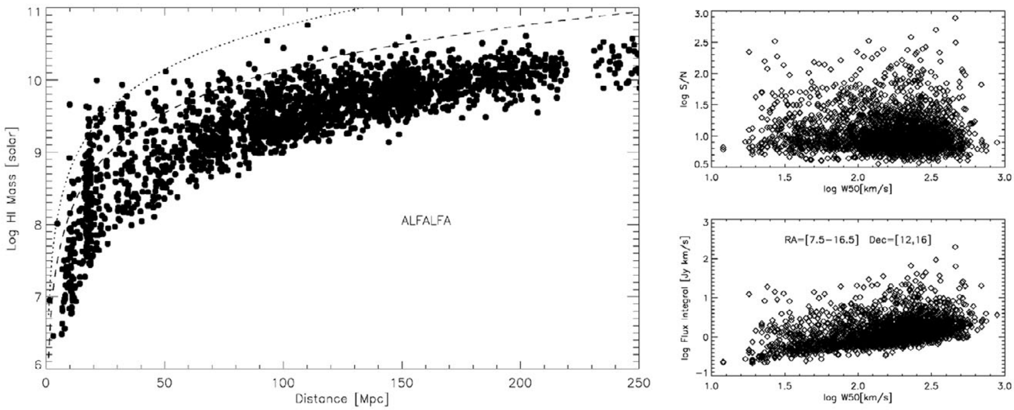

Figure 3. Left: Spänhauer plot of 2657 HI sources detected by ALFALFA in the region R.A. = $[7.5^h–16.5^h]$, Dec = $[12°–16°]$. The two smooth lines identify respectively the completeness limit (dotted) and the detection limit (dashed) for sources of 200 km s^{-1} linewidth for the HIPASS survey. Note that due to rfi, ALFALFA is effectively blind in the redshift range between approximately 15000 and 16000 km s^{-1}. **Right:** Signal–to–noise ratio vs. velocity width (top) and Flux integral vs. velocity width for the galaxies in the left–hand panel.

flux limit is ∼0.25 Jy km s^{-1} for narrow lines, rising near 1 Jy km s^{-1} for the broadest ones.

The positional accuracy of HI sources is a very important survey parameter, especially in the identification of HI sources with sources at other wavelengths, as stressed by Disney (these proceedings). The quality of the positional centroiding of a source depends roughly linearly on source S/N and inversely on the telescope beam angular size. Consider, for example, a source barely detected by HIPASS at S/N$\simeq$ 6.5. The error box of its positioning will have a radius of approximately 2.5'. The same source can be detected by ALFALFA with $S/N \simeq 50$; as the Arecibo beam is about 4 times smaller than that of Parkes, the positional error box for the ALFALFA observation is $\sim 0.1'$, making an optical identification, for example, far more reliable. Positional accuracy of ALFALFA sources averages $24''$ ($20''$ median) for all sources with S/N > 6.5 and is ∼$17''$ ($14''$ median) for signals S/N > 12.

4. Early Findings: Dark Galaxies?

What should we refer to as a "dark galaxy" (perhaps a misnomer)? Within the framework of this symposium, a dark galaxy would be a starless halo, yet detectable at other than optical wavelengths, possibly in HI or through lensing experiments. Such objects are likely to exist, but hard to find. Within the CDM galaxy formation paradigm, such objects would have relatively low mass, were unable to form stars before re–ionization and either lost their baryons or were prevented from cooling them thereafter, by the IG ionizing flux (see presentations by Hoeft and by Yepes, these proceedings). Yet we know of low mass galaxies in the Local Group which not only made stars early on, presumably before re–ionization, but they were also capable of retaining cold gas and make stars at later cosmic times. Why then should we not expect the existence of low mass systems that were unable to form stars but have retained baryons and have been able to cool them, as the IG ionizing flux rarefies? We have extremely little observational

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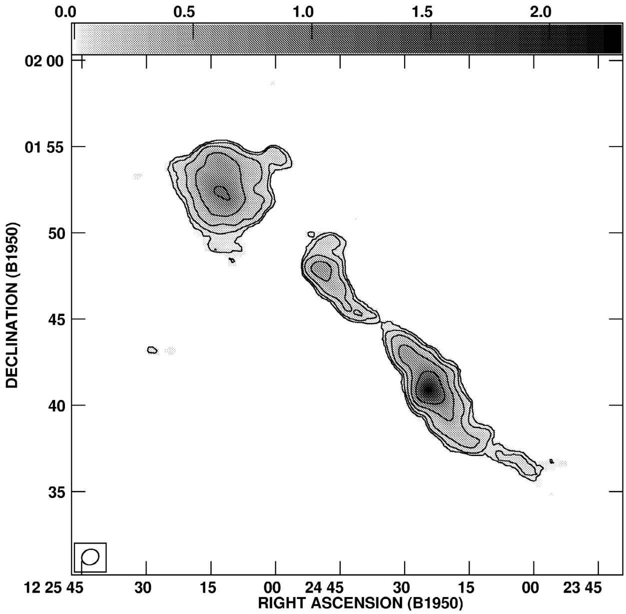

Figure 4. Zeroth moment, HI VLA map of HI1225+01, as observed by Chengalur, Giovanelli & Haynes (1995) [thanks to Ekta and Jayaram for retrieving the image].

evidence for the existence of such systems. In my view, the best "historical" example for a "dark galaxy" is the SW component of the system HI1225+01 discovered by Giovanelli & Haynes (1989). Figure 4 is a zero-th moment VLA HI map of the system, by Chengalur, Giovanelli & Haynes (1995). The NE component has an optical counterpart near its center. The SW component, however, does not: it exhibits evidence of rotation ($V_{rot} \simeq 14$, a total mass near 10^9 M$_\odot$ within a 3' ($\sim$12 kpc) radius and $M_{HI}/L > 200$. However, it is not an isolated object and it cannot be excluded that it originated from a high speed tidal encounter of the NE component with a now remote passer–by, as the system lies in the outskirts of the Virgo cluster. The burden on observers is that of finding isolated systems resembling HI1225+01SW. See Kent's presentation (these proceedings) for possible candidates. The bottom line is that, with the exception of systems found in the periphery of the Virgo cluster, ALFALFA has not unambiguously discovered any such system, so far.

5. The Case of VirgoHI21

A candidate "dark galaxy" was discovered and dubbed "VirgoHI21" (Minchin *et al.* 2007 and refs therein and these proceedings). The discovery at Jodrell Bank was corroborated by Arecibo and WSRT observations. VirgoHI21 lies some 100 kpc N of NGC4254, in the NW periphery of the Virgo cluster, projected $\sim$1 Mpc from the cluster center. ALFALFA also detects it, but the ALFALFA data strongly suggests a different interpretation for the nature of VirgoHI21. Figure 5 (left) displays contours of HI flux of ALFALFA data, superimposed on an optical image, showing a gas streamer extending some 250 kpc N of NGC 4254. The velocity field of the stream, which matches the velocity of NGC4254 to the S, is shown on the right hand side panel of the figure. VirgoHI21 is the bright section of the HI stream extending from $14°41'$ to $14°49'$. The HI mass in the disk of the galaxy is 4.3×10^9 M$_\odot$ and that associated with the stream is $5.0 \pm 0.6 \times 10^8$ M$_\odot$. One of the

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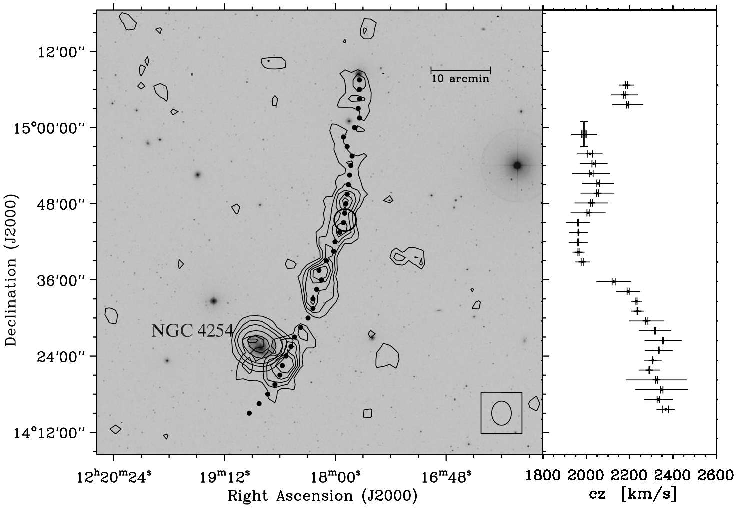

Figure 5. Left: HI column density contours extracted from the ALFALFA survey dataset, superposed on the SDSS image and centered on the position of Virgo HI21 (Minchin *et al.* 2005a). Small integer numbers superposed on the map indicate the locations of beam centers of the Arecibo observations. Contours along the stream correspond to 0.35, 0.50, 0.70, 0.87, 1.0 Jy km s^{-1} beam^{-1}, integrated from 1946 to 2259 km s^{-1}; contours around N4254 correspond to 10, 15, 20, 30, 40 Jy km s^{-1} beam^{-1}, integrated from 2259 to 2621 km s^{-1}. Right: The velocity of the HI emission peak as seen in each high S/N pointing. The horizontal bars indicate the half–power full velocity width of the HI emission. VirgoHI21 was identified as a section of the HI stream extending from $14°41'$ to $14°49'$.

driving arguments for Minchin *et al.*'s interpretation of VirgoHI21 as an isolated disk galaxy is the gradient seen in the velocity field; ALFALFA data shows that gradient to be just a part of the varying, large–scale velocity field along the stream.

NGC 4254 is a system well known for its prominent $m = 1$ southern spiral arm. It is reasonable to postulate that this special feature is related with the existence of the stream. Note the following:

• NGC 4254 moves at a large velocity with respect to the cluster (>1000 km s^{-1}) and lies at a projected distance of ∼1 Mpc from M87.

• The prominent m = 1 arm is visible in the gas and in the disk stellar population: gravity, rather than hydro phenomena such as ram pressure, is at work.

• The HI mass in the stream is only ∼10% of that in the NGC 4254 disk: the disturbance of NGC 4254 is relatively mild (it would not, in fact be classified as an HI deficient galaxy).

• The velocity field of the stream shows the coupling of the tidal force and the rotation of NGC 4254, which suggests an interesting timing argument:

(*a*) the stream exhibits memory of a full rotational cycle of the NGC 4254 disk;

(*b*) from the NGC 4254 VLA map of Phookum, Vogel and Mundy (1993), we can get the present outer radius of the HI disk (18.5 kpc) and the rotational velocity at that radius (150 km s^{-1}); from those we compute a rotation period of ≃800 Myr.

• Hence we estimate that the tidal encounter which gave rise to the stream initiated some 800 Myr ago, a time comparable with the cluster crossing time.

We conclude that the most reasonable interpretation of the system is that of a relatively mild episode of harassment, resulting from the high speed passage of NGC 4254 through

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the cluster periphery. These results are discussed in greater detail in Haynes, Giovanelli and Kent (2007).

In these proceedings, P.A. Duc (see also Duc & Bournaud 2007) presents the results of a simulation of a high speed encounter of NGC 4254 with another peripheral cluster galaxy. The simulation matches extremely well both the morphology and the velocity field of the stream. The culprit responsible for the harassment of NGC 4254 could now be located some 400 kpc to NW of NGC 4254. Duc & Bournaud speculate that, given its location and velocity, the culprit could be M 98 = NGC 4192. ALFALFA finds an extended HI appendage apparently emanating from that galaxy, as is briefly discussed in the next section.

The overall evidence for VirgoHI21 to be part of the phenomenology associated with a tidal episode of harassment, rather than an isolated "dark galaxy" is thus quite strong.

6. Other Virgo Cluster Streams: an HI Cemetery

As shown in the presentation by Kent, these proceedings, ALFALFA finds a number of HI features lacking an obvious optical counterpart. One important characteristic is in common with such systems found by ALFALFA: they appear to preponderantly be found in the Virgo cluster region. In addition, several of the systems share similarities with the NGC 4254 system: HI streams associated with disturbed galaxies, extending a few to several hundred kpc, suggesting that their origin is possibly related to high speed encounters. In this section, a brief report is given on two additional such systems.

The NGC 4532/DDO 137 pair is located in the southern part of the Virgo cluster. Using Arecibo, Hoffman *et al.* (1993) first discovered evidence that significant amounts of HI is present outside the galaxies' disks. This result was confirmed by VLA observations of the system (Hoffman *et al.* 1999), showing numerous shreds of intergalactic HI spread over tens of kpc from the optical galaxies. R. Koopmann (these proceedings) has recently discovered a complex HI stream system extending from the galaxy pair to the S, over more than 1.5° (∼450 kpc), with numerous knots which are potential sites for the formation of tidal dwarfs.

NGC 4192 = M 98 is a galaxy located in the NW periphery of the Virgo cluster, with a negative heliocentric velocity (-142 km s^{-1}) indicative of large relative motion with respect to the cluster itself. A number of HI clouds with velocities between 60 and 100 km s^{-1} are found in its vicinity, spectrally well separated from Milky Way emission. They would typically be cataloged as High (or Intermediate) Velocity Clouds, perigalactic (or Local Group) dwellers, and most of them may very well be just that. Some of the clouds, however, appear to stream out of M 98, stretching over more than 1°, well matched both spatially and kinematically to the disk of M 98. The characteristics of this system are under close scrutiny. Of particular interest is the fact that – as mentioned in the preceding section –, Duc & Bournaud suggest that M 98 may be the culprit responsible for the harassment of NGC 4254, observed in the form of the stream VirgoHI21 is a part of.

7. Conclusions

ALFALFA, the Arecibo Legacy Fast ALFA survey, is well underway. Designed to map ∼7000 sq. deg. of high galactic latitude sky in the HI line, observations for ALFALFA are 44% complete as of mid–2007. The first source catalog has been released and others are in preparation. Survey products are being placed in the public domain and accessible through NVO compatible software tools. The fully processed data are delivering an average detection rate of $\sim$5 sources deg^{-2}, with peaks 10–20 times higher in high density regions such as group and cluster peripheries. The positional accuracy of the ALFALFA HI sources is quite high, allowing unambiguous identification of $\sim$95% of them with optical counterparts. The median cz is 7800 km s^{-1}, yielding sampling of a fair cosmic volume.

Very few HI sources are not associated with optical counterparts. Those which are not generally appear as parts of tidal streams or otherwise generated appendages of known optical galaxies. The most dramatic examples of such objects in the sets of ALFALFA data examined so far are found in the vicinity of the Virgo cluster. Of particularly current interest is the stream connected to NGC 4254, which icludes VirgoHI21. ALFALFA data strongly favor the interpretation that VirgoHI21 is part of a tidal feature that resulted from a high speed encounter, rather than a *bona fide* dark galaxy.

Acknowledgements

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