Going Deep with ALFA

E-ALFA Ultra-deep field group

ABSTRACT

The improved spatial and spectral survey capabilities available with ALFA will open a new era of high sensitivity observations for the Arecibo telescope. In principle, it is possible to achieve noise of less than 50 μJy per with integration times of about 100 hours, which translates into a 1σ HI mass sensitivity of a few $10^8 M_\odot$ at a redshift of 0.16. Surveys of such sensitivity could be used to, e.g. investigate the evolution of HI gas in the universe, directly detect Lyman-limit systems, explore the low-density gas around the edges of galaxies and search for OH megamasers. Enabling ultra-sensitive observations at Arecibo would therefore open whole new fields of research to the observatory. In this proposal, we request observing time for a set of precursor observation to test the feasibility of such very deep ALFA observations and find the limitations of such observations. The proposed strategy is to obtain multiple drift scans over a field with known late-type disk galaxies close to the redshift limit and close to the optimal Arecibo declination at night. The total time request is 70 hours of observing time. The target field for this precursor proposal includes the low redshift target NGC 7523. The observations will serve as a technical test for high redshift observations and simultaneously search for extended HI emission around NGC 7523. If successful, this search will lead to the first detection of the unionized fraction of the low column-density hydrogen in emission outside the Local Group.

1. Introduction

The Arecibo dish is the largest and most sensitive instrument of its kind, making it possible to conduct unique extragalactic HI surveys which reach lower limits than surveys undertaken at other telescopes. Before the commissioning of ALFA, this possibility was never exploited because of the limited bandpass and the inefficiency of large scale surveys. However, ALFA makes it feasible, in principle, to observe down to frequencies of 1225 MHz, corresponding to 21 cm HI emission at a redshift of z=0.16. With less than 100 hours of integration time, ALFA should be able to reach a 1σ HI column density sensitivity of $10^{16}\,\mathrm{cm}^{-2}$ per 5 km s^{-1} channel for gas filling the beam. This equates to an HI mass of a few times $10^8 M_\odot$ at z=0.16.

Previous "blind" HI surveys have been limited in redshift depth and/or sensitivity (e.g. Zwaan et al. 1997, Minchin et al. 2003). The competitive advantage of a deep survey carried out with ALFA would be:

- Larger range in redshift.
- Higher spatial resolution.
- Higher velocity resolution.
- Higher sensitivity to unresolved sources.

To exploit these unique capabilities, the ALFA Extragalactic Consortium intends to propose a large scale ultra deep survey which will reach sensitivities never explored with Arecibo and which will not be explored by any other planned ALFA survey.

2. Scientific Motivation for Deep Observations

2.1. Evolution of the Gas Content of the Universe

The rate of conversion of gas into stars is one of the fundamental quantities which describe the evolution of galaxies and remains a difficult measurement to make for all but the most nearby galaxy populations (e.g. Madau et al. 1996; Haarsma et al. 2000; Bouwens et al. 2004). At redshifts between zero and unity, the global co-moving star-formation rate appears to increase by an order of magnitude. Models which attempt to explain the global evolution of galaxies (e.g. Pei et al. 1999) over this redshift range predict a corresponding sharp increase in the cosmic co-moving gas density, with $\Omega_{HI} \propto (1+z)^{3.2}$. However, the limited data we have on the gas density at these redshifts from ultra-violet observations of damped Lyman-α systems (e.g. Storrie-Lombardi & Wolfe 2000) suggests that the redshift density of absorbers with $N_H > 2\times10^{20}$ cm^{-2} only increases as $dN_{DLA}/dz = 0.05(1+z)^{1.1}$, which is consistent with constant co-moving gas density. This lack of evolution is extremely difficult to reconcile with the rapid evolution of the star-formation rate.

Several attempts have been made to match the DLAs with a population of local galaxies at z≈0 (Rao et al. 1995, Rosenberg & Schneider 2003). Number counts of optically selected galaxies seem to suggest evolution in the number densities from z≈0 to z≈ 0.5. By contrast, Rosenberg & Schneider argue that the number of galaxies found in their “blind” HI survey is consistent with the number densities of DLAs at higher redshifts. These results are based on HI surveys which can detect low-mass objects only at the lowest redshifts, and are limited in depth to z<0.03.

A deep blind HI survey could clarify the evolution of gas at redshifts < 1. Such a survey needs to be deep both in sensitivity to detect low-mass objects, and in redshift to probe the evolution of the population of HI-rich galaxies. Whilst the redshift range of ALFA to z≈ 0.16 is fairly limited in a cosmological context, it is sufficient to distinguish between the evolutionary scenarios above. The look-back time at z=0.16 corresponds to about 25% of the time between z=1 and z=0, where most of the evolution is expected to take place. Indeed other relatively shallow surveys, such as IRAS and 2dF, have detected significant evolution of luminosity and co-moving number density over similarly modest redshift ranges (for IRAS galaxies, $n(z) \propto (1+z)^3$, Takeuchi et al. 2003). A deep HI survey would provide a sample of HI emitting sources which can then be compared to both properties and number counts of local gas-rich systems and the one of the high-redshifts DLAs. However, significant integration times, careful control of observational parameters, a low system temperature, and mitigation of interference are required.

A fundamental requirement of such a deep survey is the ability to survey a large volume to the highest practical redshift ($z \approx 0.15$). In order to sample galaxies which contribute most to the mass function at $z = 0$, we need to be sensitive to M_* and sub-M_* galaxies in the range 10^9 to 10^{10} M$_\odot$. With a linewidth of 200 km s^{-1}, a galaxy with $M_{HI} = 10^{9.5}$ M$_\odot$ has an integrated flux of 0.04 Jy km s^{-1} and a mean flux density of only 0.2 mJy. A sensitivity of 0.05 mJy would allow to detect such a galaxy with 4σ significance.

We have estimated the number of detectable galaxies in a survey with 0.05 mJy sensitivity using the HI mass function by Zwaan et al. (2003). We found that in a no-evolution scenario, we would detect about 100 galaxies per square degree at $z > 0.1$ with 3σ significance. In the strong evolution scenario described above, the number of detected HI emitters should differ by 50% from that number. In order to distinguish a 50% difference in the number of detected sources with 3σ significance, at least 36 galaxies need to be detected. Therefore, the goal of the full survey would be to cover and area of 0.36 square degrees with a 0.05 mJy sensitivity.

2.2. The Cosmic Web

Evidence from QSO absorption line studies shows that the intergalactic medium is populated with low-density ionized gas, forming an important, possibly dominant reservoir of the Universe’s baryons (Shull et al. 1996; Penton et al. 2000). The structure of the clouds is still a topic of debate: theoretical modeling suggests that the absorption arises in filamentary structure (‘the cosmic web’), whereas some observers believe that the clouds are associated with the extreme outer halos of individual galaxies (Chen et al. 2001). The largest cross sections would be provided by highly ionized halos characterized by CIV absorption, followed by mainly neutral Lyman limit/MgII absorbers of HI column densities greater than a few $\times10^{17}$cm^{-2}.

The number of Lyα absorbers per unit redshift (dN/dz) generally decreases with time, but the redshift evolution suddenly becomes less steep at $z < 2$ (Weymann et al. 1996) allowing for more Ly-α absorbers at low z than one would expect from extrapolating the high-z counts. This changing evolution in absorber counts has been explained by evolution in the ionizing background intensity (Davé et al. 1999; Haardt & Madau 1996) which becomes more important than the effects of cosmological expansion at $z < 2$. However, little is known about how the ionizing background evolves at $z < 1$. Scott et al. (2002) found the intensity of the ionizing background to be decreasing at $z \sim 1$, while the flat to decreasing dN/dz values at $z \sim 0$ by Wyemann et al. (1996) are consistent with continued evolution in the ionizing intensity (Linder 2000). A crucial parameter to relate absorption line studies to the evolution of gas masses is the evolution of HI cross sections, which is largely unknown. This difficulty does not exist in emission line studies. Our proposed observations reach a 6σ column density sensitivity of $5 \times 10^{16}\mathrm{cm}^{-2}$ per 5 km s^{-1} for gas filling the beam. The Doppler parameters of the clouds are typically 30 km s^{-1} (Shull et al. 2000) and would be resolved with a proposed 5 km s^{-1} resolution.

2.3. Low column-density gas in the local Universe

The distribution of the number of absorbers along a redshift path as a function of column density (the $f(N)$ distribution) is nearly a power-law with slope -1.5 over 10 orders of magnitude. Deviations from the power-law occur at column densities where clouds become optically thin to ionizing radiation (between 10^{18} and 10^{20} cm^{-2}). The deviation from the power-law are presumably related to the ionization edge in the gaseous disks of galaxies (Maloney 1993; Corbelli & Bandiera 2002).

This region of low column densities is poorly understood in the optical because the Lyman-α line lies on the flat part of the curve-of-growth, and in the radio because typical 21-cm observations do not reach this column density sensitivity. Only two Local Group galaxies have so far been mapped to sufficient details at low enough column densities. This lack of statistics around 10^{17} – 10^{18} cm^{-2} has so far made it impossible to discriminate between different models for ionization. An ultra deep survey with ALFA can vastly improve the statistics by surveying the outer edges of galaxies which are located beyond the Local Group.

2.4. Extragalactic OH Megamaser Emission

The study of merging galaxies may hold the key to understanding two important astrophysical phenomena – the galactic merger environment in which a significant fraction of the stars in the universe likely formed, and the evolutionary connection between galaxy mergers and AGNs.

The extreme physical conditions in advanced merger systems could, in some cases, induce nuclear OH masing up to 10^6 times stronger than typical galactic masers (Baan 1989; Briggs 1998). According to the classical model, the OH emission originates in a several hundred pc extended molecular screen, producing low-gain, unsaturated amplification of the diffuse nuclear background continuum of the galaxy. The pumping is provided by the intense far-IR emission.

At low redshifts, several Ultra-Luminous IR galaxies (ULIRGs), which are advanced mergers, show strong OH 18 cm megamaser activity. Well known examples of such galaxies are Arp 220 (z=0.018) and IRAS 17208-0014 (z=0.043). The 1667 MHz megamaser emission from these galaxies is $\geq 10^3\, L_\odot$.

Any deep survey of a large enough field is likely to include strong IR emitting galaxies. The wide bandwidth and the unprecedented sensitivity of a deep ALFA survey will make it possible to detect OH megamaser emission up to redshifts $z \sim 0.4$. Assuming similar megamaser emission to nearby ULIRGs, the peak flux density of the 1667 OH megamaser line is expected to be about 1 mJy at $z \sim 0.4$.

2.5. Extragalactic HI Absorption

Another scientific outcome of a deep HI survey would be the study of HI absorption seen on the line of sight toward weak background continuum sources. A 0.25 mJy peak HI absorption detection toward a 15 mJy background continuum source corresponds to an optical depth of $\tau = 0.017$. Assuming a FWHM velocity of $20\, km\, s^{-1}$, the resulting column density is $N_{HI} \sim 7 \times 10^{17}\,\mathrm{cm}^{-2}\,\mathrm{K}^{-1} \times \mathrm{T}_{\mathrm{spin}}$. If the foreground galaxies also exhibit HI emission, then a direct measurement of the neutral hydrogen spin temperature in these galaxies would be possible (e.g.

Lane & Briggs, 2001).

3. The ALFA Ultra Deep Survey (AUDS)

3.1. Ultra Deep Observations

One of the proposals which will be submitted by the E-ALFA consortium is the **A**LFA **U**ltra **D**eep **S**urvey (AUDS), designed to address the science goals discussed in section 2. The deep observations require sensitivities close to 0.05 mJy per 5 km/sec bandpass. This sensitivity and spectral resolution are necessary to detect low mass systems at high redshift. If the observed noise σ in spectra relates to integration time $t_{\rm int}$ as $\sigma \propto \sqrt{1/t_{int}}$ even for extremely long integration times, then the measured performance of ALFA (gain$\approx$ 10 K/Jy, $T_{sys} \approx 30\,$K) suggests that such sensitivities could be reached with about 50 hours of integration time per beam in total power mode. However, such a sensitivity cannot be reached by integrating on a single pointing for extended periods of time, mainly because of baseline subtraction issues such as standing waves. We believe that these problems can be overcome in a drift scan mode, the details of which are given below. With that technique sources will spend only a fraction of the drift time in the center of the beam. We estimate that the on-source integration time requirement in a drift scan mode is about 50% more than in a staring total power mode. AUDS will therefore eventually require to survey about 0.36 square degrees with 75 hours of integration time per beam, which will require a total of about 1000 hours of integration time.

3.2. Proposed Observing Strategy

To reach the deepest possible observations with ALFA, we propose to observe in a "drift and chase" mode. For that purpose, we will rotate the feed array to an orientation so that a single position on the sky drifts through the three central beams. The basic strategy is to point 10 arcmin ahead of the target field with the central beam. We will then let the sky drift past for 1.3 min of time (or 20 arcmin). Subsequently, we will drive to the starting point and repeat the procedure.

We believe that the highest possible sensitivity can be reached with such a technique for the following reasons:

- "ON" and "OFF" source integrations are sampled as close in time as is possible, which is good for removing temporal changes in receiver gain, interference, and ground spillover. Active scans, which have been successfully used with other radiotelescopes such as Parkes, lead in principle to even better tracking of temporal behavior. However, active scanning at Arecibo causes major changes in the received interference and spillover components, which offsets any advantage from better tracking of temporal behavior.
- ALFA will be stationary during each drift, and will rotate to track the sky only between drifts. Rotation of ALFA, which is necessary for long integration which follow the source, would degrade the data.
- Drift scans provide extra spatial information which can be very useful in discriminating between sky signal and interference.

An additional advantage of drift scanning is that positions and fluxes of sources can be measured at the full telescope resolution at least in scanning direction. The goal of the AUDS will be to obtain fully Nyquist-sampled 2-d maps. Drift scans will be the most efficient way of obtaining such maps.

4. Proposal for Precursor Survey

4.1. Goals

The total integration time to reach the cosmological interesting sensitivity outlined above is 75 hour per beam. Because of RFI, standing waves, baseline subtraction issues and hardware noise limitation, it is not clear whether such integration times achieve the theoretical expectations for noise. We therefore propose to carry out precursor observations to test whether ultra-deep observations for surveys such as AUDS are possible with ALFA. Our proposal is to test the "drift and chase" method with a total integration time of 35 hours per beam on a single field on the sky. Assuming $\sigma \propto 1/\sqrt{t_{\rm int}}$, the noise in the final spectra will be within a factor $\sqrt{2}$ of the requirements for the AUDS survey. This proposal is the only one submitted by the E-ALFA consortium to test the "drift and chase" method.

The proposed setup of the survey is identical to the one for the full AUDS survey. We will use the WAPPS with 200 MHz bandwidth. In order to spectroscopically resolve low mass systems, we will use the full 5 km/sec resolution. For interference mitigation, we will use the highest time resolution permitted. We estimate that with our "drift and chase" mode, our goal to reach 35 hours of on-source integration time in the most sensitivity part of the survey can be achieved in a total of 70 hours of scheduled observing time.

The goal of these observations is to test the feasibility and efficiency of our proposed observing mode and evaluate whether noise as a function of integration times keeps decreasing at the expected rate for such long exposure times. If it does not, we will attempt to identify and quantify any additional sources of noise. By collecting repeated observations of the same source over an extended period of time, we will be able to investigate stability and robustness of calibration of the whole system.

The data for these precursor observations will characterize the ALFA system and will therefore be useful for calibration purposes and as a reference of low-level effects and intermittent effects. We also intend to experiment with new RFI excision and baseline subtraction methods based on cross-correlating signal from different feeds, and through rapid dumping of the backend data.

Results from this experiment will be:

- RMS noise as a function of integration time for frequencies throughout the ALFA bandwidth
- Characterization of low-level RFI and identification of RFI-free regions of the spectrum, investigation of methods to mitigate low-level RFI
- quantification of gain stability over the period of observation
- quantification of sensitivity limits due to baseline artifacts and standing waves

In addition to the technical goals for this proposal, we aim to detect the unionized part of the low column-density hydrogen in emission for the first time outside the Local Group (see section 4.4).

4.2. Survey Area

Currently only 4 of ALFA's feeds can be used when the full 200 MHz bandwidth is utilized. We intend to use the four available beams as follows. Feed 1, 2 and 3 will be oriented to pass over the same area on the sky. The central part of the covered area will be seen by one of the beam approximately half of the actual observing time and the highest sensitivity will be reached for that area. We have chosen a target field with known high-redshift galaxies to be placed in that part of the survey (see section 4.3). Our choice for the fourth available beam is to use feed 4a. The resulting geometry of the drift survey is shown in figure 1. Our target area was chosen so that the sky area covered by that feed includes a low-redshift target.

4.3. Target Selection

The prime objective of the precursor proposal is to test whether the sensitivity goals described in section 2.1 can be reached. For that purpose, we have selected a region of the sky that contains several high-redshift galaxies within an area which can be covered by the proposed 1.3 minute drift scans. In addition, we aimed to include a relatively nearby galaxy suitable for searches of the low column-density gas as described in section 2.3. Our final target field satisfies both these goals.

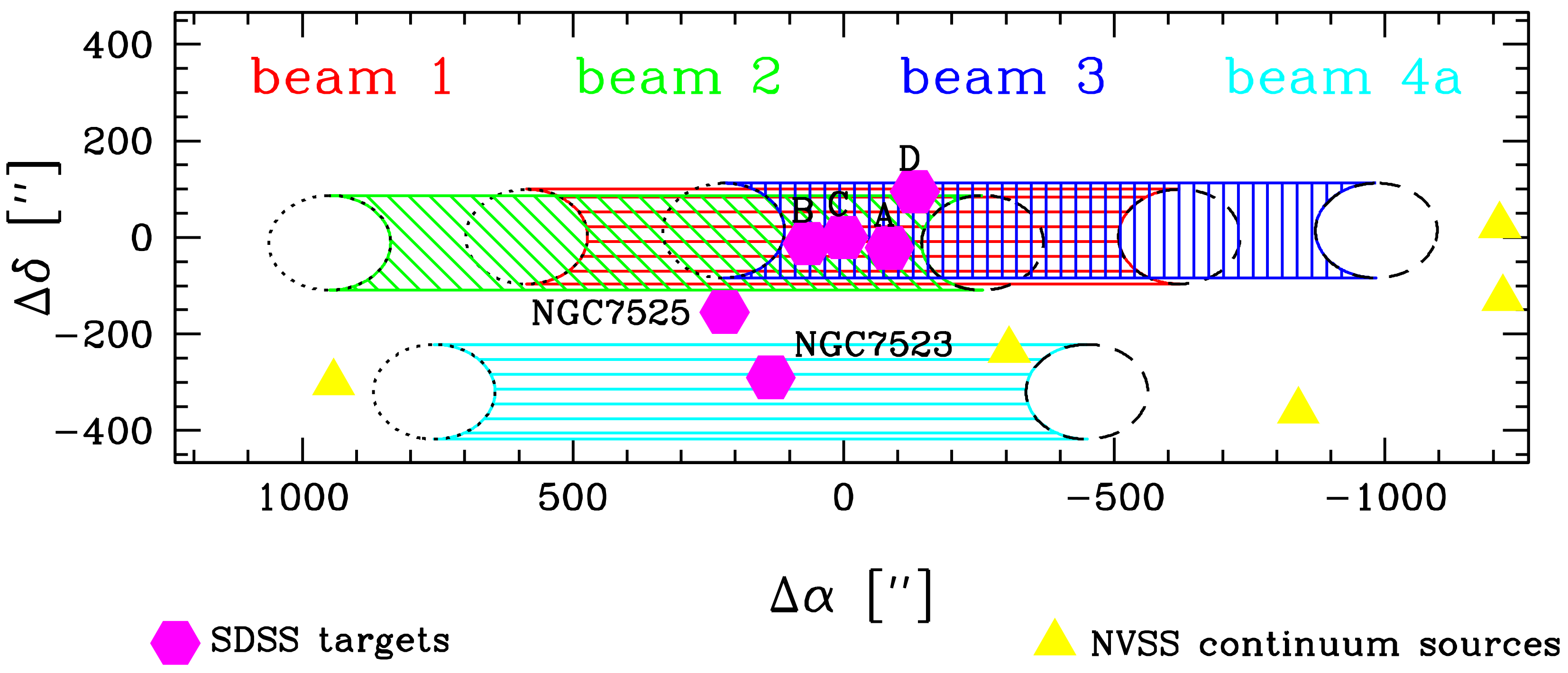

Fig. 1.— *Geometry of the proposed 1.3 minute drifts through our target field. The start positions of the four chosen beams are shown as dashed lines, and the end positions as dotted lines. The start and end position of each beam are connected through shaded areas which are the part of the sky which fully traverse that beam in each scan. Only the central part of the scanned area traverses all three beams in each scan. Also shown are the position of the SDSS target galaxies (filled hexagons) (see section 4.3) and strong NVSS continuum sources (filled triangles).*

Our specific procedure for the field selection was as follows. We have used the *Sloan Digital Sky Survey* (SDSS) spectroscopic sample to identify a field with the following characteristics: (a) observable from Arecibo during nighttime between October and December; (b) including at least one HI-rich galaxy in the redshift range $0.093 \le z \le 0.118$, corresponding the relatively RFI-free frequency window 1270–1300 MHz; (c) including at least one HI-rich galaxy at lower redshift; and (d) not contaminated by strong continuum radio sources. More in detail, we used the *SDSS DR2 Sky Server* to select good candidates for HI detection in the 1270–1300 MHz frequency window, and visually inspected the SDSS images of the 146 galaxies at redshift $z \ge 0.100$, looking for presence of additional disk galaxies within a few arcmin from the main target. Finally, we searched the *NRAO VLA Sky Survey* (NVSS) for any continuum sources brighter than 10 mJy close to our survey area.

The exact selection criteria for *good HI candidates* are identical to the ones successfully used by Catinella, Haynes, Giovanelli, Gardner and Connolly (2004, private communication) to identify HI rich galaxies at intermediate redshifts ($z \le 0.25$) detectable with Arecibo (project A1803). Preliminary results demonstrating the success of such selection technique have been presented on several occasions (e.g. Catinella's invited talk at the Arecibo Observatory, April 5th 2004).

The field selected for these precursor observations is shown in Figure 2. It includes 6 objects (labeled A through F) that are all within 8 arcmin from each other, and are also well distributed in redshift (see Table 1). All targets are also identified in figure 1. The high-redshift targets are located close to the most sensitive part of the survey, and are within the redshift range of interest. They are well suited to test our algorithms for signal extraction in the presence of strong RFI. The local galaxy, NGC 7523 is conveniently located so that it can be covered by feed 4a. There are in total five bright continuum sources within 10 arcmin of the proposed drift (see table 2). The faintest of the five sources with a flux density of 11.4 mJy will be passed over by beam 4a. This is not a major concern since this beam does not cover the region which requires the highest sensitivity. In the worst case, the continuum source might lead to some of the data of this feed to be of lower quality. We will investigate the impact of continuum emission for deep HI observations and the possibility to search for HI absorption using that part of the data.

4.4. Science Goals of Precursor Sources

The high-redshift scientific goals of the AUDS require large enough samples for statistical investigations. These goals can therefore only be reached once a sufficiently large area on the sky has been mapped. However, the convenient location of NGC 7523 close to our high-redshift targets allows us to use the precursor experiment to carry out a search for low-density gas around this galaxy and such both demonstrate the feasibility of the experiment described in section 2.3 and obtain a scientific result. By integrating for a minimum of 10 hours per beam, which we will do over the whole area of the precursor survey ($\sim$ 180 sq. arcmin), we should reach a 5σ

Table 1. SDSS Galaxies in Figure 2.

ID	SDSS designation	z	Freq. (MHz)
A	SDSS J231320.5+140340.9	0.114	1275
B	SDSS J231330.3+140349.7	0.040	1366
C	SDSS J231326.0+140402.5	0.091	1302
D	SDSS J231317.5+140537.2	0.061	1339
E[a]	SDSS J231334.7+135912.4	0.040	1366
F[b]	SDSS J231340.2+140127.8	0.040	1366

[a] NGC 7523.

[b] NGC 7525 (galaxy pair; the entry refers to the NW component.)

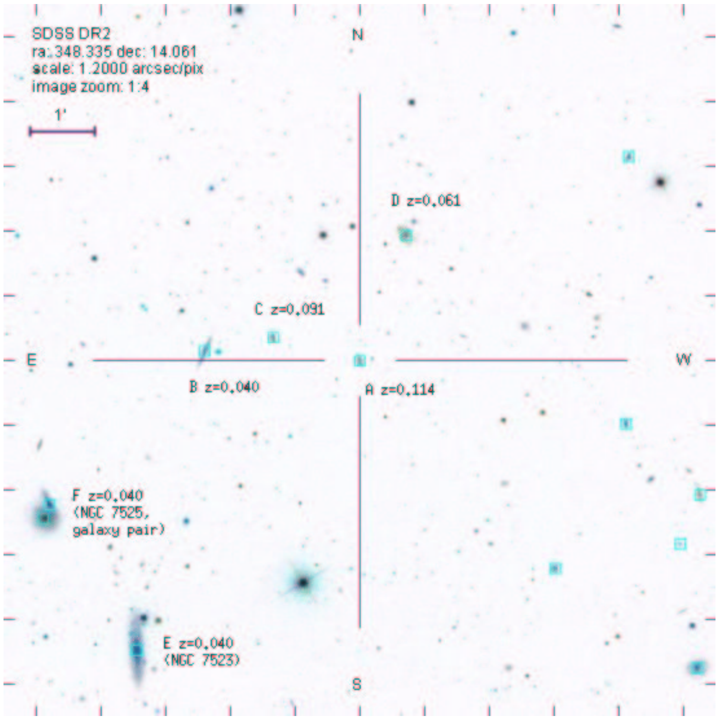

Fig. 2.— *SDSS image of the selected field. The small squares show targets included in the SDSS spectroscopic sample.*

column-density limit of $N_{HI} \leq 7 \times 10^{16}$ cm^{-2} for sources 10 km s^{-1} wide that fill the beam. This is well below the lower end of the 'ionization gap' seen in QSO absorption statistics between 10^{18} and 10^{20} cm^{-2}. Even with this precursor observations, we should therefore be able to detect the unionized fraction of the low column-density hydrogen in emission for the first time outside the Local Group.

Beam 4a will be positioned to pass over NGC 7523 at $z = 0.04$. At this distance, the Arecibo beam has a radius of $\sim 85h_{0.7}^{-1}$ kpc, thus the higher column-density, unionized gas should be confined within a single beam. The expected impact parameter of the low column-density, ionized gas $\sim 250h_{0.7}^{-1}$ kpc, translates to 1.5 Arecibo beam widths at this distance. Careful modeling of the beam side lobes will be required to remove contamination, but we will be able to draw on the results of other E-ALFA precursor proposals in order to carry this out.

Table 2. Bright NSVV Sources in Target Field

α (J2000)	δ (J2000)	offset α ["]	offset δ ["]	S [mJy]
23 12 04.93	+14 01 58.8	-1218	-126	34.3
23 12 05.27	+14 04 25.5	-1212	24	17.4
23 12 29.91	+13 58 4.1	-840	-360	11.4
23 13 05.49	+14 00 7.7	-306	-234	26.7
23 14 28.94	+13 59 4.8	942	-300	201.3

In addition to NGC 7523 itself, it is possible that there is gas associated with the NGC 7523 / 7525 group, either as part of the IGM or as interaction debris. Much of the volume of the group will be probed by our survey, with beam 4a probing the area around NGC 7523 and the other three beams probing a region 5 arcmin north of this including the group galaxy SDSS J231330.3+140349.7. We should therefore be able to detect any such low column-density component if it is present.

4.5. Data Reduction

An essential part for the success of the proposed experiment is the ability to process the data efficiently. Our team has significant experience with the multibeam receiver at the Parkes radiotelescope and its data reduction system. As part of the proposed pre-cursor experiment, we intend to adapt Parkes software to handle the ALFA data we will collect in this experiment. Starting from existing software packages will reduce the cost of this effort. Nevertheless, we are fully aware that software development will take time and require substantial investments. We believe that we have both the expertise and resources to convert existing software for our purposes.

Particularly relevant to the proposed observations are the data reduction methods used to process data from the HI Parkes All-Sky Survey (HIPASS). These methods are transferable, either directly in software, or in technique, to the AUDS observations proposed here. Significant overlap in team membership between these two projects will facilitate the transfer process.

As detailed in Barnes et al. (2001) and Meyer et al. (2004), initial processing of HIPASS data was completed in real-time at the observatory using the LIVEDATA package. Spectra are bandpass corrected using temporally adjacent off-source data. These are then gridded using median statistics with the GRIDZILLA package to produce the position-position-velocity cube main data product.

Specific processing requirements not presently covered by HIPASS software that will be developed for E-ALFA include: improved methods of bandpass correction; cleaning to remove the effects of strong continuum sources; and advanced methods for the treatment of radio frequency interference. Tests will also be run to assess the impact of the factor $\approx$5 increase in data rate of the proposed observations compared to HIPASS.

4.6. Relation to other Surveys

One issue which must be explored both for the planned AUDS survey as well as for a number of the planned extragalactic and possibly also galactic surveys, is the noise of the ALFA system as a function of total integration time. For example, the E-ALFA Arecibo Galactic Environment Surveys (AGES) plans to look at areas in the sky for anywhere from 120 – 600 seconds, or more, while AUDS will be looking at a given area of the sky for a total of 70 hours. Before embarking on either of these large surveys we must ensure both that no systematic noise in the ALFA system prevents the r.m.s. noise from integrating down as $1/\sqrt{t_{\rm int}}$, and that baseline issue similarly do not prevent any observers from reaching the theoretical noise level.

A second issue which will be examined by this precursor proposal and will be of importance to all of the E-ALFA surveys, is the characteristics of the frequency band from 1215 – 1425 MHz. For this proposal we plan on using only four of the ALFA receivers (but alternating between the receivers used), allowing the WAPP back ends to be configured for 200 MHz of simultaneous observing. This will mimic the observing conditions which will be achieved once the backend for the E-ALFA consortium is completed. The primary reasons for wishing to observe the full 200 MHZ which will be available to E-ALFA are to determine the system noise across the entire band, determine the system gain and temperature, over an extended period of time, across the entire band, and to perform a complete characterization of the properties of the Radio Frequency Interference (RFI) across the band. Additionally, having data covering the final bandwidth of the E-ALFA consortia surveys will allow the consortia to develop all necessary software for data reduction across this band, including all RFI excision software which may be needed.

Finally, any drift scan survey will benefit from software development, and we intend to closely coordinate our efforts with the the AGES and ALFALFA survey teams.

5. References

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