2013 Undergraduate ALFALFA Team Workshop

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Abstract

The 2013 Undergraduate ALFALFA Team (UAT) workshop will perform follow-up observations on targets from the Arecibo Legacy Fast ALFA (ALFALFA) survey on January 13 - 16. The ALFALFA survey is a blind survey of extragalactic neutral hydrogen. Associated research works towards identifying and cataloging over 35,000 HI sources in the local universe (up to $z \sim 0.06$). Followup observations of ~150 sources will be completed during the undergraduate workshop using the L-Band Wide (LBW) receiver with a 1320-hipass filter. Potentially the most interesting follow-up objects are dark galaxy candidates without optical counterparts. The higher sensitivity, longer exposures by LBW also allow us to confirm or reject weak detections in ALFALFA that could be additional dark galaxy candidates, OH megamasers, high velocity clouds, or tidal debris.

Scientific Background

Observations of the 21cm spectral line emitted by neutral hydrogen gas have enabled astronomers to look at the structure, formation and environmental interactions of galaxies up to high redshifts. October 24th marked the completion of the Arecibo Legacy Fast ALFA (ALFALFA) HI survey after almost 5,000 hours of observations. The survey covers an area of 7000 deg^2 within a declination range of 0° to +36° with right ascension from $07h\ 30'$ to $16h\ 30'$ and $22h\ 00'$ to $3h\ 00'$(Giovanelli et al. 2005). Over 35,000 HI sources in the local universe up to a redshift of $z \sim 0.06$ have been catalogued. This survey allowed us to probe the faint end of the HI Mass Function (HIMF) while also searching for sources without optical counterparts. The first 40% of the ALFALFA data has been published in the $\alpha 40$ catalog (Haynes et al. 2011). This catalog includes the heliocentric velocities, HI flux densities, distances, signal-to-noise ratios and other spectral data for 15,855 detected sources. Of these sources, 199 are believed to be extragalactic sources without optical counterparts. In addition to high signal-to-noise sources that are published, ALFALFA also catalogs many sources that have lower signal-to-noise or may be affected by radio frequency interference. Many of these also lack optical counterparts. These sources require follow-up observations to discern whether the detections are dark galaxies, OH megamasers (OHM), High-Velocity Clouds (HVC) within our own Milky Way galaxy, or tidal debris.

Dark galaxies candidates are of particular interest because they have important implications for the widely accepted cosmological model, Λ Cold Dark Matter (ΛCDM) theory, which describes the universe as flat and having low matter-density (Klypin et al. 1999). This model has predicted many large-scale observations of the universe (Peacock et al. 2001; Jaffe et al. 2001) however high-resolution simulations predict a fair number of dwarf galaxies in the halos of massive galaxies (Kypin et al. 1999; Moore et al. 1999). These predictions are contrary to observations. Either the formation of the predicted halos must be prevented, or they must be hid by suppressing star formations (Verde et al. 2002). A confirmed dark galaxy will offer support to settle this dispute.

Proposed Observations

The ALFALFA Team is working with the Undergraduate ALFALFA Team (UAT) to followup ALFALFA detections. As part of the program, students and faculty are attending the UAT workshop. Preceding teleconferences and activities prepare students with a base knowledge they will need to enter the workshop. During the workshop, the UAT will use the L-Band Wide Receiver (LBW) in 4 observing sessions on Jan 13 - 16 to conduct pointed observations of ALFALFA detections requiring confirmation. This invaluable experience will allow students to understand the motivation behind the observations, and how to implement them.

The LBW is a single-pixel detector, but is more sensitive than ALFA. To obtain lower noise observations than ALFALFA, we will track specific target positions over a longer time than ALFALFA's integration of 40 seconds. The LBW's bandwidth ranges from 1120-1730 MHz. However, we will implement a 1320 hipass filter to help mitigate radio frequency interference (RFI) resulting in a final bandwidth of 1280 - 1470 MHz.

Our observations will implement the On-Off method. During the on exposure, the target will be tracked actively by the telescope. Next, the telescope will then be moved to the position of the object at the beginning of the observation in order to flat field the image. We will observe blank sky over the same altitude and azimuth path travleled by the target. These two exposures will allow us to subtract the background from the target source, decreasing the noise in the detection. On and off pair exposures take $\sim$7 minutes total, 3 minutes on source, 1 minute to move the dish and 3 minutes off source followed by a 10 second Cal On, and a 10 second Cal Off.

The pointing position will depend on the type of object being observed. Pointings for objects without optical counterpart candidates will be positioned at the original HI detection position while pointings or objects with optical counterpart candidates will be positioned at the candidate location.

Focus of Observations

About 150 objects will be observed over the course of four nights. These objects are all either weak detections with possible optical counterparts (OC), dark galaxy candidates, or possible OH megamasers. A sample of six of representative targets and their descriptions are provided below. Table I describes the details of each sample object: whether or not an OC is associated with the detection, the heliocentric velocity, v50, the full width at half maximum, W50, the shape of spectrum profile and the signal to noise ratio (SNR). Fig. 1 and Fig. 2 provide the ALFALFA spectra and the Sloan Digital Sky Survey (SDSS) optical images respectively for each object.

• HI081801.6+00405 is an OH megmaser (OHM) candidate considering it has a strong detection of SNR=7.7, possesses a highly blue-shifted velocity, v50 = -1340 km s^{-1} and coincides with an implausible OC. It is possible for a strong OH line to be red-shifted into the frequency range ALFALFA detects as an HI signal. We highly doubt this could be an HVC because the majority of confirmed HVCs possess a red-shifted velocity on the order of magnitude of a few hundred km s^{-1}.

• HI081700.9+170356 and HI131623.7+161640 are significant dark galaxy candidates, with the former catalogued in the α40 catalog. Their high SNRs and lack of OCs are strong evidence for dark galaxies.

• HI111307.9+291615 is a low SNR detection with possible a OC in the form of an irregular galaxy about 40$''$ North West of the detection.

• HI124614.3+020130 is another low SNR detection with an associated faint edge-on galaxy about 80$''$ North West of the detection but appears to be of similar redshift according to an SDSS spectrum. This is a possible case of tidal debris.

• HI125722.3+025937 is another low SNR detection. An associated faint, edge-on galaxy is about 10$''$ North of the detection.

Observations of these objects and other similar ones will help define the reliability of the detections from ALFALFA. Follow-up optical imaging should be pursued to confirm a lack of an OC in addition to further HI observations at higher spatial resolution to study the gas dynamics should the detections be real.

TABLE I
Target Details

Object	Right Ascension	Declination	OC	v50 km s^{-1}	W50 km s^{-1}	Spectrum Profile	SNR
HI081700.9+170356	08h 17$'$01.4$''$	+17°04$'$13$''$	no	419	20	Gaussian	6.8
HI081801.6+004057	08h 18$'$01.7$''$	+00°41$'$09$''$	no	-1340	14	Gaussian	7.7
HI111307.9+291615	11h 13$'$09.5$''$	+29°16$'$23$''$	yes	601	23	Gaussian	3.8
HI124614.3+020130	12h 46$'$14.2$''$	+02°01$'$31$''$	yes	902	15	Gaussian	3.3
HI125722.3+025937	12h 57$'$22.5$''$	+02°59$'$41$''$	yes	2873	60	Double-horned	4.3
HI131623.7+161640	13h 16$'$24.2$''$	+16°16$'$43$''$	no	353	16	Guassian	6.4

Figure 1: Shows the detection spectra as shown in ALFALFA's data reduction IDL routine, galcat. The large peak centered at 0 km s^{-1} is Milky Way HI emission. The detection for HI124614.3+020130 is at 900 km s^{-1}.

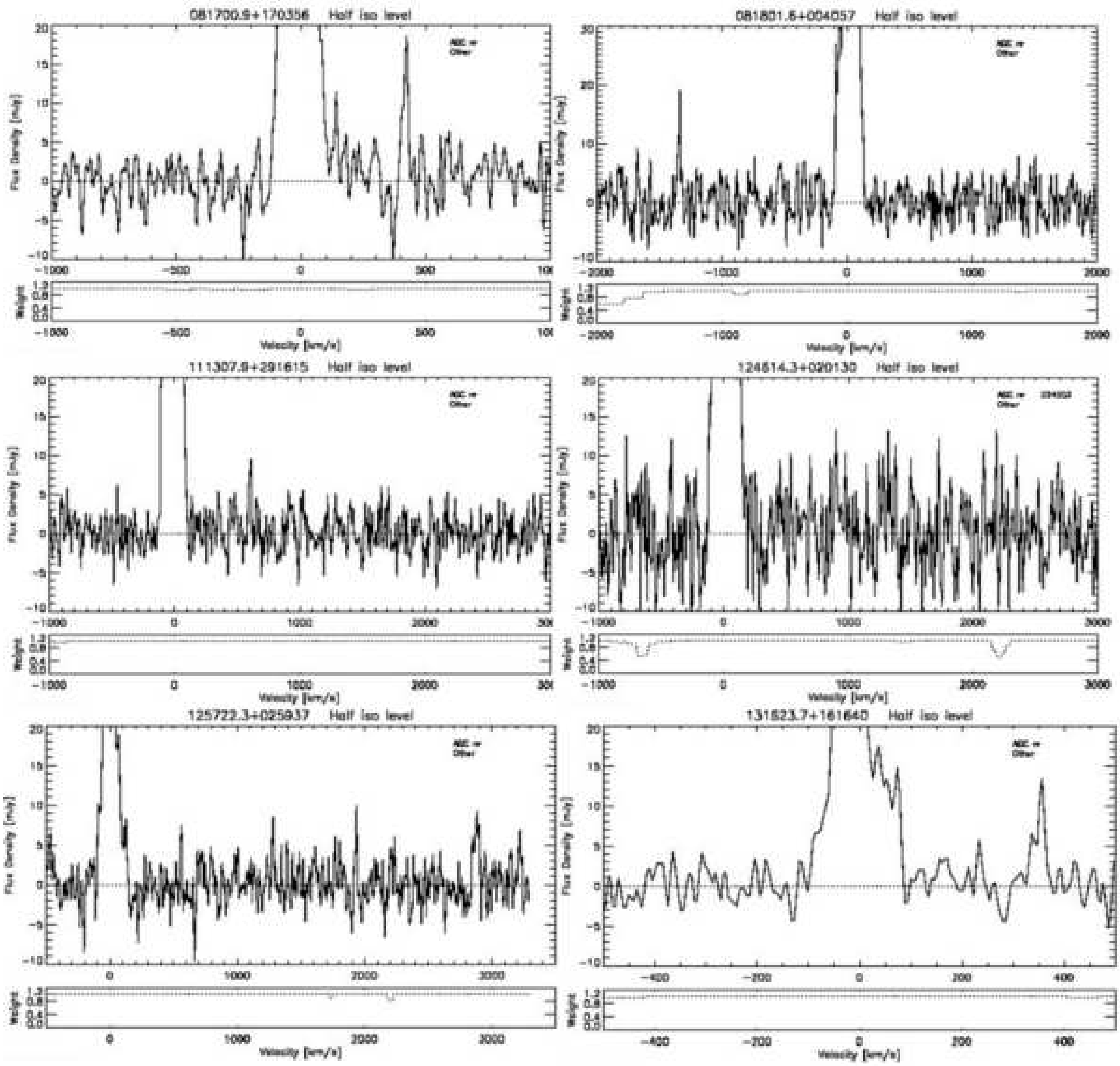
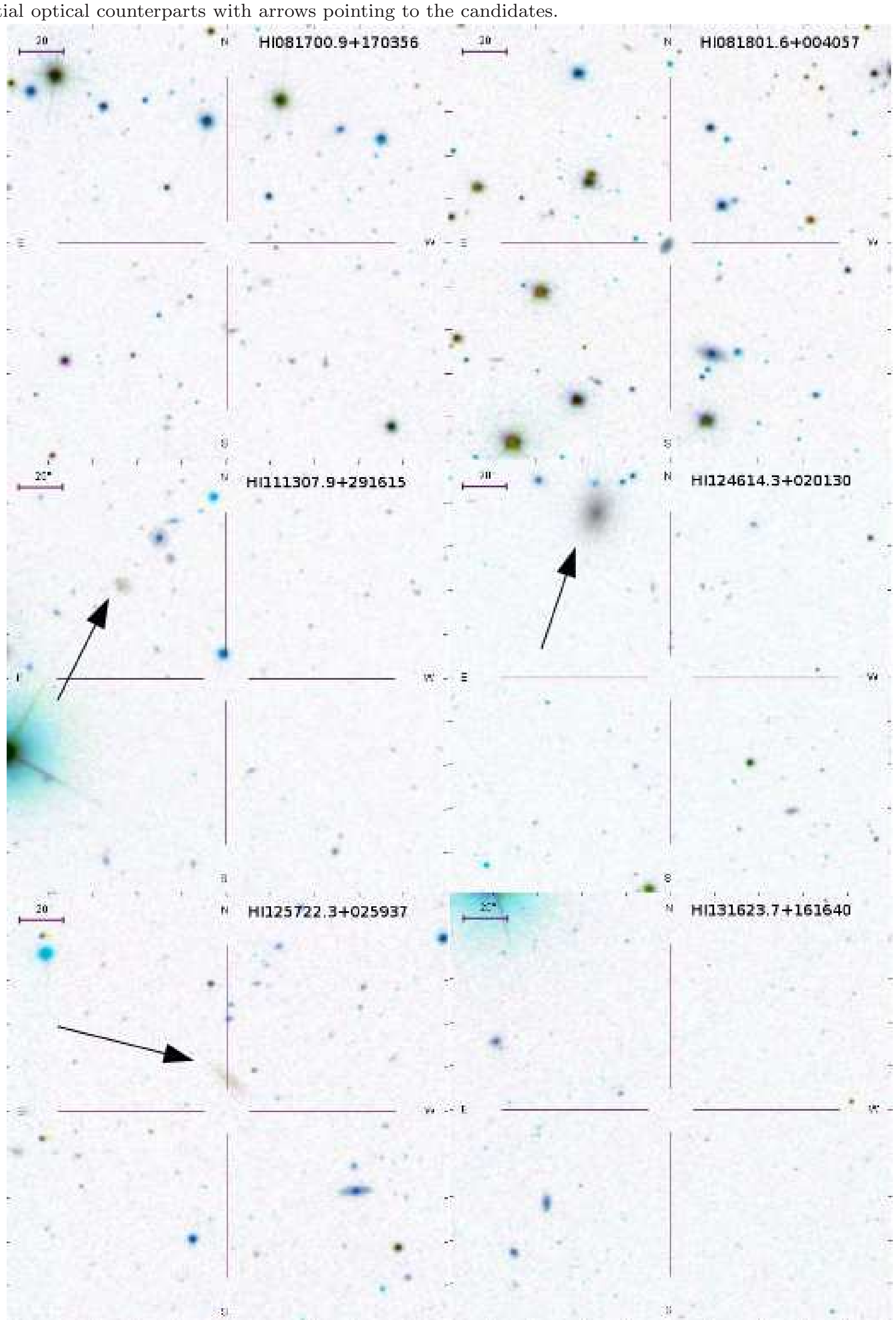


Figure 2: Optical SDSS imaging of each object. Note that HI111307.9+291615, HI124614.3+020130, and HI125722.3+025937 have potential optical counterparts with arrows pointing to the candidates.



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