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Introduction

Three “Harvesting ALFALFA” Arecibo observing programs in the direction of the Pisces-Perseus Supercluster (PPS) were completed since ALFALFA observations were finished in 2012.



Arecibo Legacy Fast ALFA¹ Survey

Blind extragalactic neutral hydrogen (HI) spectral line survey covering 7,000 square degrees of the sky. Observing in frequencies between 1,345 MHz and 1,435 MHz allowed detection of HI source velocities of ~3,000 km/s to +19,200 km/s with 5 km/s resolution at a Hubble distance of 270 Mpc, $z \leq 0.06$. Observations began on February 4, 2005 and were completed on October 26, 2012.

40% of the data were released in 2011 (α .40, Haynes et al., 2011), 70% in 2015 and the preliminary release of α .100, has begun at <http://legallabro.cornell.edu/alfalfa/data/>.

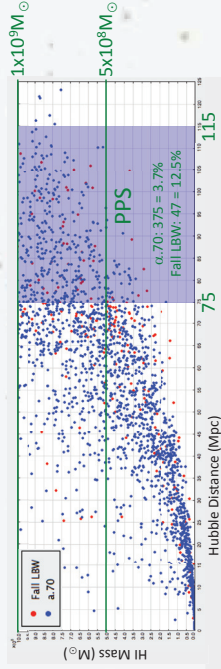
¹ Arecibo L-band Feed Array

Pisces-Perseus Supercluster

PPS is the nearest supercluster to Milky Way Galaxy beyond Laniakea. (Tully et al., 2014). We seek to explore the distribution and peculiar velocities of galaxies and clusters to determine the underlying distribution of dark matter in the large scale structures of the universe.

PPS has been found to be a wall of clusters roughly $5h^{-1}$ Mpc to $10h^{-1}$ Mpc deep extending at least $50h^{-1}$ Mpc from the Perseus to Pegasus Clusters with a significant overdensity of galaxies at a heliocentric velocity of about 5,000 km/s. (Wegner et al., 1993). There are also foreground and background voids, allowing more accurate determinations of infall velocities of galaxies on each side of the main ridge of the supercluster.

At the distance of PPS, only about 4% of α .70 sources (in blue below) have HI masses lower than $10^9 M_{\odot}$. In order to explore PPS and the intervening void, more low mass galaxies are needed. The Fall LBW observations, with 12.5% of detections below $10^9 M_{\odot}$ paved the way for the Arecibo Pisces-Perseus Supercluster Survey (APPS). See Davis et al. 347.40 and Craig et al. 132.03.



Arecibo Observatory Observation Programs

Harvesting ALFALFA: L-band Wide Followup of Enigmatic ALFALFA sources II

A2707 Haynes et al. Fall 2012, Detected 35 of 128 targets

- 1) Confirm reality of high S/N dark galaxies (determine which ones are OH Megamassers),
 - 2) Identify real sources among low S/N, low z ($cz < 1000$ km/s), narrow ($W50 < 80$ km/s) candidate signals
- 51 hours of 3-min ON-OFF-pairs with Interim Correlator, centered on source's ALFALFA heliocentric velocity

Harvesting ALFALFA: Reaping the 21cm Harvest in the Pisces-Perseus Supercluster and the Foreground Void

A2811 Haynes et al., Fall 2013, Detected 184 of 239 targets

- 1) Verify ALFALFA Code 4's (low S/N with OC of unknown z)
 - 2) Increase number of galaxies with measured redshifts
- 42 hours of 3-min ON-OFF-pairs with Interim Correlator, centered on source's ALFALFA heliocentric velocity

Harvesting ALFALFA: Discovering Galaxies in the Pisces-Perseus Void

A2899 Koopmann et al., Fall 2014, Det. 167 of 218 targets

- 1) Use ALFALFA, SDSS & GALEX to investigate galaxies in & around the PPS Void to test formation & evolution models in low density regions,
 - 2) Increase number of galaxies with measured redshifts
 - 3) Verify more ALFALFA code 4's (low S/N with OC of unknown z)
- 40 hours of 3-min ON-OFF-pairs with WAPPS in Search Mode.

Targets & Detections

ALFALFA sources were classified according to their signal-to-noise ratio (S/N) and presence of an optical counterpart (OC). High S/N sources (> 6.5) have a 95% confidence level, though some THAT lack an OC may be spurious. Low S/N ($4.5 < S/N < 6.5$) sources with an OC were thought to be real, but required corroborating observations. Low S/N sources lacking an OC were thought to be spurious. The first two observing programs focused on these.

In the process of seeking optical counterparts in the Sloan Digital Sky Survey (SDSS) data releases, similar galaxies not detected by ALFALFA were discovered. Few of these had spectra, so the had to be chosen by photometric criteria. Becoming familiar with these allowed the development of an SQL query to select galaxies likely to be at the distance of the PPS.

References

Haynes, M. P., Giovanelli, R., Martin, A., et al. 2011, *AJ*, 141, 124
Saintonge, A., 2007, *AJ*, 133, 2087
Saintonge, A., Giovanelli, R., Haynes, M. P., et al. 2008, *AJ*, 135, 588
Tully, R. B., Courtois, H., Hoffman, Y., & Pomarède, D. 2014, *Nature*, 513, 71
Wegner, G., Haynes, M. P., & Giovanelli, R., 1993, *AJ*, 105, 1251

Acknowledgements

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Selected from	A2707	A2811	A2899
High S/N	Det. 27 NoDet. 4	Det. 3 NoDet. 0	Det. -- NoDet. --
Low S/N + OC	5 0	4 82	133 --
Low S/N no OC	0 0	0 0	77 0
Totals	32 26.2	90 70.0	57 77
Det. Rate (%)	77	30	58.0

Selected from	A2707	A2811	A2899
Photometry	Det. 0 NoDet. 2	Det. 24 NoDet. 4	Det. 61 NoDet. 18
Known z	-- 0	-- 8	-- 1
Totals	0 0.0	24 85.7	69 78.4
Det. Rate (%)	78.4	78.4	78.4

Discussion

- Some high signal-to-noise ALFALFA sources are spurious
Detected 30 of 34
Saintonge, A., 2007, *AJ*, 133, 2087 ... some are spurious
- Did observe some high signal-to-noise targets
No Optical Counterpart
Near cut-off ($S/N = 6.5$)
- Low signal-to-noise ALFALFA sources without an OC are spurious
Detected 0 of 83 ... yes, ZERO
These are very unlikely to be real
... enough gas for ALFALFA to detect $\Rightarrow$ there will be stars!
- Low signal-to-noise ALFALFA sources with OCs are likely to be real
Detected 215 of 305
Those not detected may be too distant
- LBW targets can be successfully selected by photometric criteria and ranges defined in SQL queries.

Observation Methods

Pointed basic Total-Power Position-Switched Spectral Observations in 1340 – 1430 MHz ALFALFA frequency range.

- 3 minutes on source, return to original position
- 3 minutes on blank sky along same altitude-azimuth path

Frequency Band Selection

- 1) Known Redshifts: Arecibo Interim 50 MHz Correlator bands centered on source frequency
 - 2 low-resolution spectra (1 in each polarization)
 - 2048 channels across 25 MHz (12 kHz, 2.6 km/s per channel)
- 2 high-resolution spectra (1 in each polarization)
- 2048 channels across 6.25 MHz (3 kHz, 0.6 km/s per channel)
- 9-level sampling
- 2) Unknown Redshifts: Wideband Arecibo Pulsar Processors (WAPPS) Search Mode across entire ALFALFA bandwidth
 - 4 staggered spectra (1 in each polarization)
 - 1024 channels across 25 MHz (12 kHz or 2.6 km/s per channel)

