The UAT Groups Project: The HI Mass Function for Galaxies in Groups

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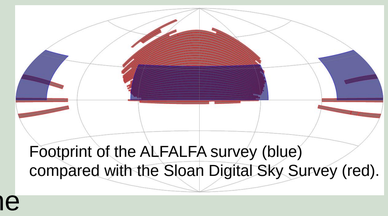
The HI Mass Function

The HI mass function is cosmologically important as a test of structure formation models and as a measure of the contribution of HI to the total mass of the universe.

We are particularly interested in whether galaxy interactions in groups modify the HI mass function. HI gas may, for example, be tidally drawn out, merged with other galaxies, or destroyed in starbursts.

ALFALFA and the UAT Groups Project

The Arecibo Legacy Fast ALFA (ALFALFA) survey is a blind HI survey optimized to detect galaxies in the local universe. The current catalog, 40% complete, includes over 15,000 extragalactic sources out to a distance of about 250 Mpc (Haynes et al. 2011).



Footprint of the ALFALFA survey (blue) compared with the Sloan Digital Sky Survey (red).

The Undergraduate ALFALFA Team Groups project focuses on the HI properties of galaxies in twelve well-studied groups as a subset of the full ALFALFA survey. Participation by undergraduates is supported by NSF grants for summer research, workshops, computers and software, and travel to conferences and to the Arecibo telescope.

Here we present the composite mass function for seven of the twelve groups in the UAT Groups project. These are selected to have full coverage ALFALFA coverage and—in order to have very well-defined completeness limits—no significant radio frequency interference at the 21 cm at their redshift.

UAT Groups Project Sample

groups in **bold** are used for our mass function calculation

NGC 5846	29 Mpc	
WBL 368	72 Mpc	
HGC 69	90 Mpc	RF interference
MKW 10	92 Mpc	
NGC 5416/ZW 1400	95 Mpc	
MKW 11	103 Mpc	
WBL 404	105 Mpc	
MKW 8	120 Mpc	data incomplete
WBL 251	128 Mpc	RF interference
NGC 6107	133 Mpc	data incomplete; RF interference
AWM 4	139 Mpc	data incomplete
A 2063	152 Mpc	

References and Acknowledgments

Haynes, M. et al., 2011, The Astronomical Journal, 142, 170.
Martin, A. et al., 2010, The Astrophysical Journal, 723, 1359.

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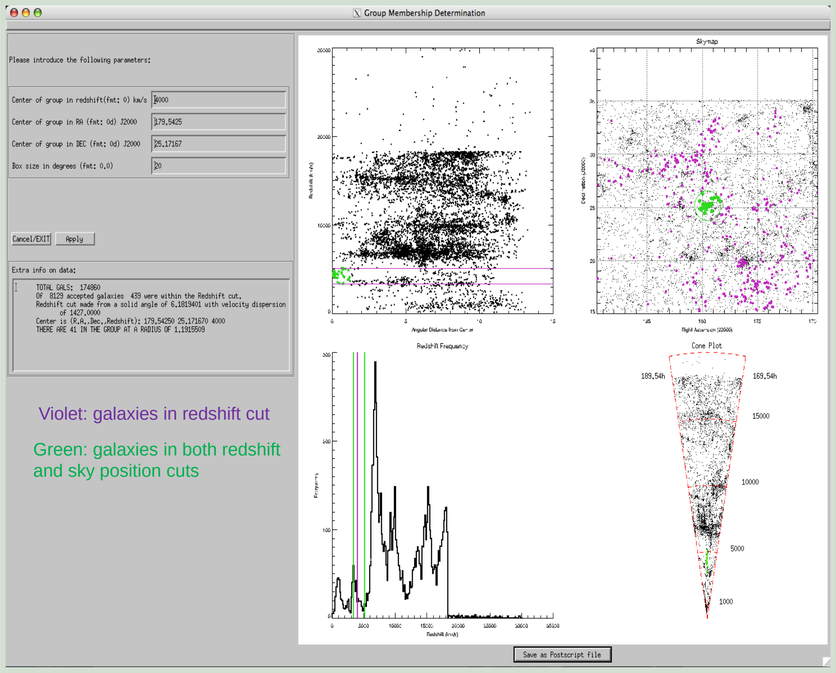
Determining Group Membership

We define the region for each group using the Arecibo General Catalog, a catalog complied by ALFALFA project members from both HI and optical sources. We select galaxies in redshift space by going out from the central redshift until the standard deviation in redshift increases sharply (by twice the average for three galaxies in a row). We then select galaxies by position in the sky by going out from the center position until the density profile flattens (changes by less than 50% for three galaxies in row.) The results for WBL 368 are shown below.

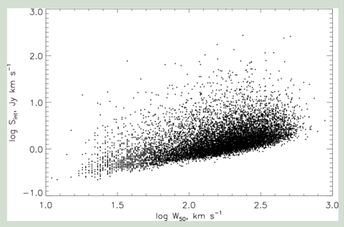


Violet: galaxies in redshift cut

Green: galaxies in both redshift and sky position cuts

Completeness

Detection sensitivity depends on both integrated flux S_{int} and line width W_{50} (Martin et al. 2010).



We use Code 1 ALFALFA sources based on two selection criteria, similar to those used to calculate the HI Mass function for the full 40% ALFALFA survey:

1) Only sources with integrated flux > 1.8 JY km/s (expected completeness near 100%; Haynes et al. 2011). The mass function in each bin is normalized by the total volume of groups at distances where detections at this mass would be complete.

2) All Code 1 sources, using a $1/V_{max}$ weighting to correct for sources that would not be detected in all groups. The maximum distance at which a source would be seen is determined by comparing the integrated flux with the cutoff flux for the particular width of each source:

$$\log S_{cut} = 0.5 \log W_{50} - 1.14, \quad \log W_{50} < 2.5$$
$$= \log W_{50} - 2.36, \quad \log W_{50} > 2.5$$

The maximum volume V_{max} out to which each source could be seen is the volume of all groups out to this distance.

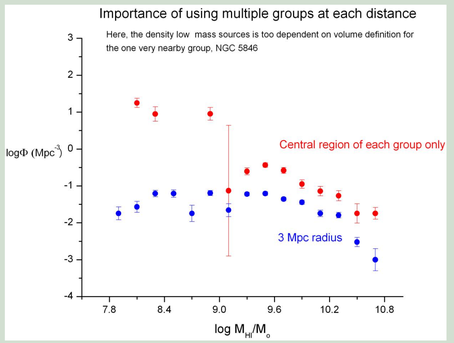
Uncertainty in Mass

Mass uncertainties are dominated by ~10% uncertainties in distance, corresponding to ~20% uncertainty in HI mass,.

$$M_{HI} = 2.36 \times 10^5 \text{ (distance}^{2)} \text{ (Integrated flux in Jy km/s)}$$

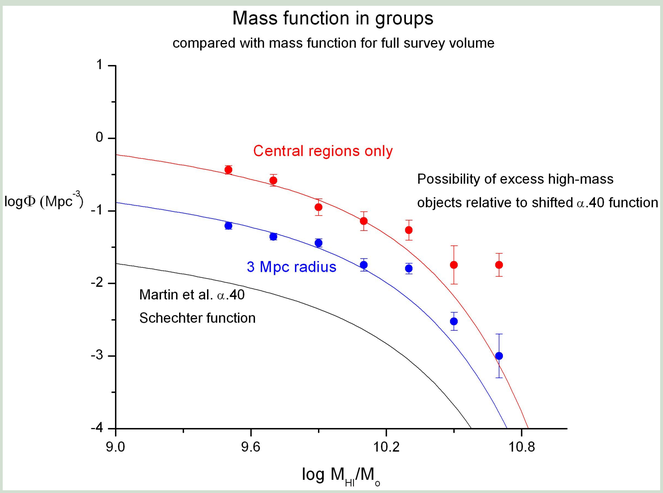
Sensitivity to Structure in Individual Groups

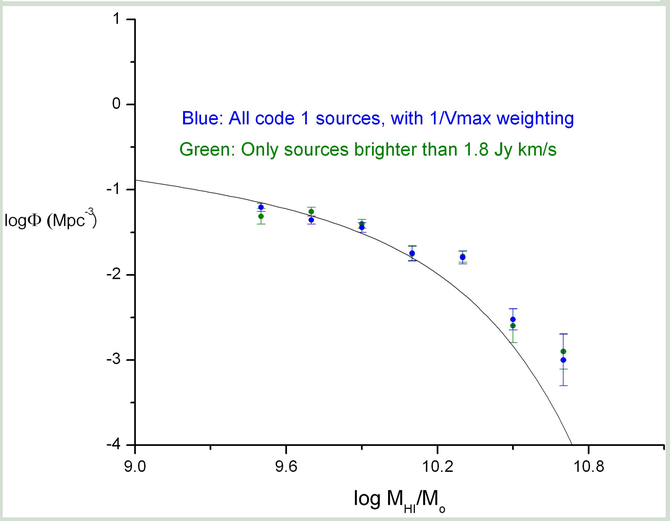
If nearby groups are difference from distance groups then different mass bins will pick up different kinds of objects and give an inaccurate picture of the full mass function. In order to minimize this problem, we consider the mass function to be reliably determined only for masses that include information from at least half of the groups in the sample. This figure illustrates an extreme example of this problem. Data for the very low mass bins are provided by only the close group NGC 5846, with an especially small central region.



Results

- The composite mass function for our sample is statistically consistent with a shifted (denser) version of the Schechter function that fits the entire 40% ALFALFA survey.
- There is a possibility of **more high mass sources relative to low-mass sources** that may be confirmed when a larger sample is available.





"Central regions" refers to the regions selected by the group membership algorithm described above (ranging from 0.30 Mpc to 1.7 Mpc) . We also calculate the mass function using a uniform radius of 3 Mpc for each group and the redshift cut from the group membership algorithm.

Error bars show one-sigma errors from Monte Carlo simulations that include Gaussian distributed distance errors with a standard deviation of 10%.

Asterisks mark mass bins to which fewer than half the groups have contributed, and are therefore less reliable.