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The H I mass function and velocity width function of void galaxies in the Arecibo Legacy Fast ALFA Survey

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Abstract

We measure the H I mass function (HIMF) and velocity width function (WF) across environments over a range of masses, $7.2 < \log(M_{\text{HI}}/M_{\odot}) < 10.8$, and profile widths, $1.3 \log(\text{km s}^{-1}) < \log(W) < 2.9 \log(\text{km s}^{-1})$, using a catalogue of ~ 7300 H I-selected galaxies from the Arecibo Legacy Fast ALFA (ALFALFA) Survey, located in the region of sky where ALFALFA and Sloan Digital Sky Survey (Data Release 7) North overlap. We divide our galaxy sample into those that reside in large-scale voids (void galaxies) and those that live in denser regions (wall galaxies). We find the void HIMF to be well fitted by a Schechter function with normalization $\Phi^* = (1.37 \pm 0.1) \times 10^{-2} h^3 \text{ Mpc}^{-3}$, characteristic mass $\log(M_{\text{HI}}^*/M_{\odot}) + 2 \log h_{70} = 9.86 \pm 0.02$, and low-mass-end slope $\alpha = -1.29 \pm 0.02$. Similarly, for wall galaxies, we find best-fitting parameters $\Phi^* = (1.82 \pm 0.03) \times 10^{-2} h^3 \text{ Mpc}^{-3}$, $\log(M_{\text{HI}}^*/M_{\odot}) + 2 \log h_{70} = 10.00 \pm 0.01$, and $\alpha = -1.35 \pm 0.01$. We conclude that void galaxies typically have slightly lower H I masses than their non-void counterparts, which is in agreement with the dark matter (DM) halo mass function shift in voids assuming a simple relationship between DM mass and H I mass. We also find that the low-mass slope of the void HIMF is similar to that of the wall HIMF suggesting that there is either no excess of low-mass galaxies in voids or there is an abundance of intermediate H I mass galaxies. We fit a modified Schechter function to the ALFALFA void WF and determine its best-fitting parameters to be $\Phi^* = 0.21 \pm 0.1 h^3 \text{ Mpc}^{-3}$, $\log(W^*) = 2.13 \pm 0.3$, $\alpha = 0.52 \pm 0.5$, and high-width slope $\beta = 1.3 \pm 0.4$. For wall galaxies, the WF parameters are $\Phi^* = 0.022 \pm 0.009 h^3 \text{ Mpc}^{-3}$, $\log(W^*) = 2.62 \pm 0.5$, $\alpha = -0.64 \pm 0.2$, and $\beta = 3.58 \pm 1.5$. Because of large uncertainties on the void and wall WFs, we cannot conclude whether the WF is dependent on the environment.

Key words methods: statistical galaxies: distances and redshifts
galaxies: luminosity function, mass function cosmology: observations
large-scale structure of Universe radio lines: galaxies

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