The HI Environment of Nearby Ly−alpha Absorbers

M.A. Zamojski, J.H. van Gorkom, S. Giovanardi (*Columbia University*), J.E. Hibbard (*NRAO, Charlottesville*), J.T. Stocke (*University of Colorado*)

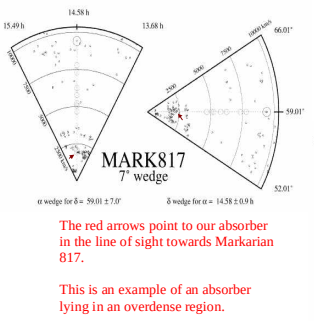
ABSTRACT

We present HI observations of the environment of three nearby (~ 2000−2500 km s^{-1}) Ly−α absorbers. The absorbers are located along the sight lines towards Markarian 817, Markarian 509 and VII Zwicky 118. The one towards Mrk 817 is located in a supercluster region, while the remaining two are located in voids. We used a mosaicing technique to probe volumes that extend to 400 h_{70}^{-1} kpc or more in transverse distance from each of the absorbers and have 1300 km s^{-1} of depth. Our sensitivity limits vary from $3.2\times10^7\ h_{70}^{-2}\ M_\odot$ to $6.4\times10^7\ h_{70}^{-2}\ M_\odot$. We detect four galaxies around the absorber towards Mrk 817, but also, for the first time, we find a galaxy next to an absorber located in a void. We also combine these results with previous investigations of five other Ly−α absorbing systems to address statistical questions. We thus find, by comparing to the HI mass function, that there is 4 to 5 times more HI around Ly−α absorbers than on average in the sky.

INTRODUCTION

Numerical simulations (Dave' et al. 1999) as well as recent optical observations (Penton et al. 2000, 2002) show that low−redshift Ly−α absorbers tend to follow the same large−scale distribution as galaxies, but are rarely associated with individual galaxies per say. Some absorbers even appear to occur in isolation which seems to indicate that some of them might be primordial in nature. The possibility remains though for the absorption lines to be due to faint intervening galaxies along the line of sight (in particular LSBs). In order to investigate this question, McLin et al. (2002) have launched a deep pencil−beam redshift search in the optical around void absorbers, but found no galaxies.

We present results from a deep HI survey of the environment of three nearby Ly−α absorbers. We selected very nearby (~ 2000−2500 km s^{-1}) absorbers in order to obtain good sensitivity, and used wide−field mosaicing to probe to significant transverse distances. We further combine our results with previous investigations of five other Ly−α absorbing systems in an attempt to statistically quantify their HI environment.



The red arrows point to our absorber in the line of sight towards Markarian 817.

This is an example of an absorber lying in an overdense region.

The blue arrows point to our absorber in the line of sight towards Markarian 509.

This is an example of an absorber located in a void.

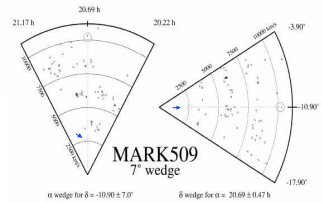


FIG. 1. − Pie diagrams of the sight lines towards Mrk 817 and Mrk 509 taken from Penton et al. (2000). Letters represent galaxies. Dotted circles represent locations of Ly−α absorbers along the line of sight. Galaxy positions are based on the CfA redshift survey.

OUR DETECTIONS

We detected four galaxies in the sightline towards Mrk 817 and one towards Mrk 509. No HI was found in the environment of the VII Zw 118 absorber. Figure 2 shows HI contours of the galaxies in the environment of the absorber towards Mrk 817 superimposed on the optical DSS image of the same region of the sky. Two galaxies were cataloged, UGC 9391 (upper right galaxy) and UGC 9477 (upper left galaxy), and two were not. The distance of each galaxy to the line of sight is also shown on figure 2.

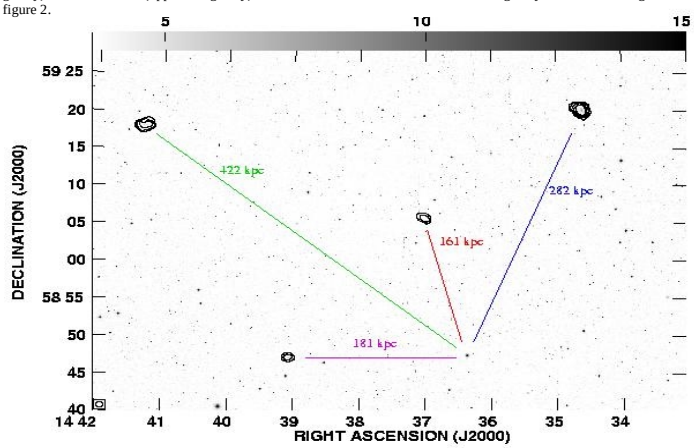


FIG. 2. − Contour map of the total HI emission from objects in our mosaic of the region around Mrk 817 overlaid on the DSS image of the same portion of the sky. Contour levels represent column densities of 0.5, 1.4, 2.9, 4.1 $\times10^{20}\ cm^{-2}$. The distance of each galaxy to the line of sight is also shown. All galaxies are within 300 km s^{-1} of the absorber.

We also found a tiny galaxy in the sightline towards Mrk 509 (shown in Figure 2). This galaxy has an HI mass of only $8.5\times10^7\ h_{70}^{-2}\ M_\odot$ to $1.3\times10^8\ h_{70}^{-2}\ M_\odot$ depending on whether we consider the North−Western extension as real or simply as a noise peak (see Figure 2). It is 415 h_{70}^{-1} kpc away from the line of sight in transverse distance and 300 km s^{-1} in velocity. This is the first time a galaxy is detected in the environment of a Ly−α absorber that is located in a void!

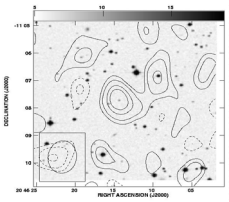


FIG. 3. − Total HI emission from the galaxy next to the Mrk 509 Ly−α absorber overlaid on the DSS image of the same portion of the sky. Contour levels are at column densities of −4.1,−2.5, −1.5, 1.5, 2.5, 4.1, $5.2\times10^{20}\ cm^{-2}$.

STATISTICAL ANALYSIS

By combining our data with previous ones (Shull et al. 1998; van Gorkom et al. 1996) we have addressed the following questions: "What is our detection rate of HI when looking around Ly−α absorbers compared to unbiased HI surveys?", and "How do HI mass, equivalent width of the absorption line and distance to the line of sight correlate with each other?"

In order to answer the first question we built an HI mass function with all the combined data and compared it with average HI mass functions given by Zwaan et al. (1997) and Rosenberg et al. (2002), see figure 3. By integrating the HIMF, we found that we have ~ 4 to 5 times more HI in our sample than would have been expected in a blind survey!

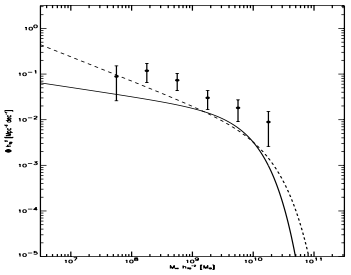


FIG. 4. − Number, Θ, of galaxies per Mpc^3 per decade of mass in our sample compared to the HIMF given in Zwaan et al. (1997) − solid line − and in Rosenberg et al. (2002) − dashed line.

In an attempt to address our second question, we have plotted in figure 5, for every galaxy in our sample, the log of its HI mass vs. its distance to the line of sight and the equivalent width of the absorption line. From this figure, it seems that higher mass galaxies are found farther from Ly−α absorbers than lower mass ones.

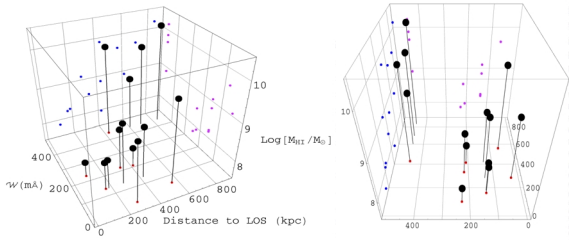


FIG. 5. − 3Dplot, viewed from two different angles, of the log of HI mass vs. distance to the line of sight and equivalent width of the absorption line for every galaxy in our sample. Projections onto each plane are also shown. Galaxies nearest to the absorbers are identified by red dots.

CONCLUSIONS

- In consistency with simulations and optical observations, we find that some nearby Ly−α absorbers seem to be related to galaxies while others occur in isolation.
- We see hints that Ly−α absorbers tend to avoid regions of space very close to galaxies.
- We detect 4 to 5 times more HI in our sample, which consists of regions around nearby Ly−α absorbers, than would have been expected from a blind survey.
- The question remains, however, as whether our increased detection is due to the Ly−α absorbers themselves or whether it is due to the fact that Ly−α absorbers are predominantly found in slightly overdense regions. This is where our work stands so far, but we hope to be able to answer this question in the very near future.

REFERENCES

Dave', R., Hernquist, L., Katz, N., & Weinberg, D. H. 1999, ApJ, 511, 521

McLin, K. M., Stocke, J. T., Weymann, R. J., Penton, S. V., & Shull, J. M. 2002, ApJ, 574, L115

Penton, S. V., Stocke, J. T., & Shull, J. M. 2000, ApJS, 130, 121

−. 2002, ApJ, 565, 720

Rosenberg, J. L., Schneider, S. E. 2002, ApJ, 567, 247

Shull, J. M., Penton, S. V., Stocke, J. T., Giroux, M. L., van Gorkom, J. H., Lee, Y. H., & Carilli, C. 1998, AJ, 116, 2094

van Gorkom, J. H., Carilli, C. L., Stocke, J. T., Perlman, E. S., & Shull, J. M. 1996, AJ, 112, 1397

Zwaan, M. A., Briggs, F. H., & Sprayberry, D. 1997, ApJ, 490, 173