ZEEMAN-SPLITTING OPPORTUNITIES FROM GALFA

1. THE HI SKY AT 3.4 ARCMIN RESOLUTION

Figure 1 shows a GALFA map of a somewhat arbitrarily-chosen ~ 500 deg^2 area at two velocities, –13.2 and +39.9 km s^{-1}. The enhanced detail afforded by GALFA's unique combination of angular resolution and surface-brightness sensitivity is the difference between a blobby mush and the clarity required to discern the kinematical and morphological details.

At the $v = -13.2$ km s^{-1} of the left-hand panel, the HI is local and lies in the negative-velocity tail of the profiles. The most prominent HI structures are long, thin filaments with some blobby substructure, giving the impression of shocks. Being on the tail, these filaments have lots of kinetic energy per unit mass and their appearance gives feeling that the energy comes from some external source (stellar winds? supernovae?)—as opposed to simply being a result of intermittency in turbulence.

At the $v = +39.9$ km s^{-1} of the right-hand panel, Galactic rotation puts the distance at ~ 2.9 kpc. The HI structure breaks up into discrete clouds, some of which are connected by weaker filaments; at the center of the map these clouds lie 750 pc off of the Galactic plane. We strongly suspect these clouds to be the counterparts of Lockman's (2002) discrete halo clouds, and eagerly anticipate studying their statistics.

Our GALFA data show that HI clouds with similar properties to the Lockman clouds also reside in the outer Galaxy! Figure 2 shows three striking clouds. They are easily recognizable when, as here, they kinematically follow the Galactic disk but at a velocity that is offset by 10 to 20 km s^{-1} from that of the bulk HI emission. Our data reveal many of these: numerous small (a few pc in size) and cold ($T_{\rm k} < 400$ K and probably $T_{\rm k} \ll 400$ K) HI clouds in the outer Galaxy located at $|z| \sim$60–900 pc (Stanimirovic et al. 2006).

GALFA provides maps of innumerable such structures with the full resolution and sensitivity capabilities of the Arecibo telescope. By piggybacking on other groups we are realizing our goal of surveying the full Arecibo sky, and we do not anticipate a need to make such maps after the survey is finished. So... what's next?

2. MAGNETIC FIELDS!

We often see clouds and filamentary or sheet-like structure, and often one is embedded in the other. This combination of observed sheets/filaments and clouds is familiar to theorists who perform numerical simulations. Such structures result from compressed regions in colliding clouds that undergo thermal instabilities with concomitant amplification of magnetic fields (e.g. Audit & Hennebelle 2005). These simulations confirm speculations that stringy interstellar structures are probably intimately related to interstellar magnetic fields.

The structures pictured in Figures 1 and 2 are very well-suited for observing Zeeman splitting in the 21-cm emission line. They are well-defined and quite isolated in the three-space of position/velocity. This is important, because telescope sidelobes tend to be polarized; this introduces significant instrumental errors in the measurement of Zeeman splitting when the HI structures are extended and blended together with unrelated structures. In such blended cases, reliable measure-

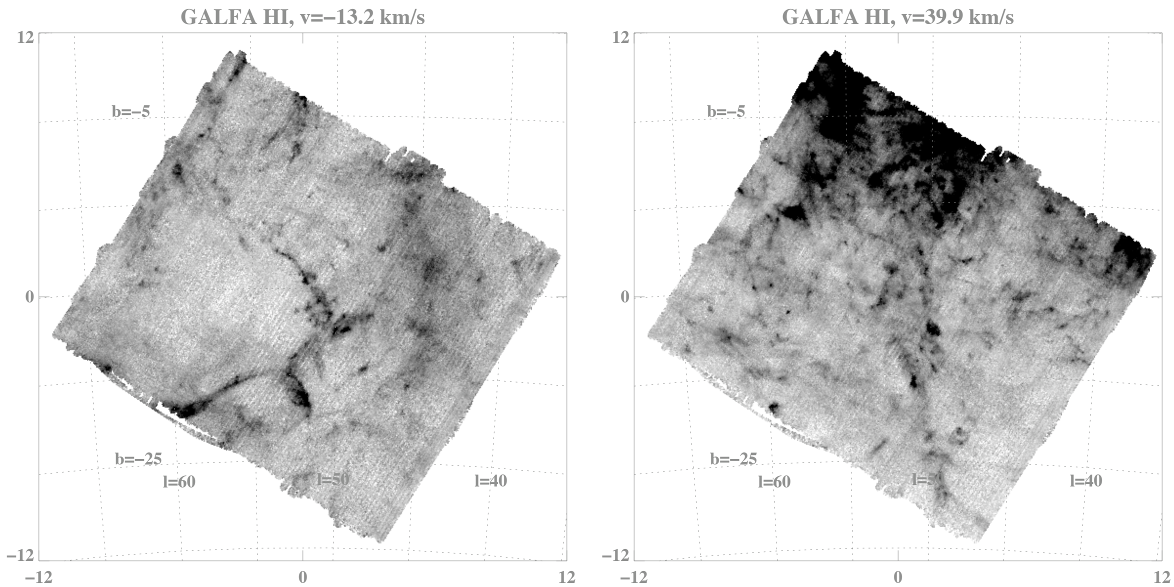

Fig. 1.— GALFA maps of a ~ 500 deg^2 area centered near $(\ell, b) = (50^\circ, 0^\circ)$ at two velocities, −13.2 km s^{-1} and +39.9 km s^{-1}. The data are shown in the underappreciated stereographic projection, which is one of the very few projections that is *conformal*, which means that shapes are locally preserved.

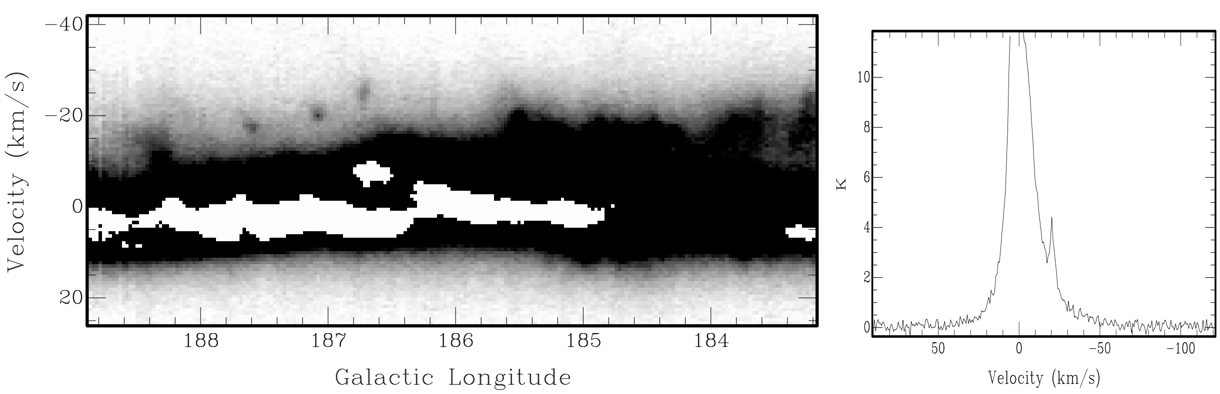

Fig. 2.— (Left) A GALFA longitude-velocity diagram at $b = 18^\circ$. Three small halo clouds near $(\ell, V) \sim (187^\circ, -20$ km s$^{-1})$ are prominent. These clouds have an angular size of only $4'$ and a velocity linewidth of only 2 km s^{-1}. All pixels with $T_{\rm B} > 10$ K have been masked out to enhance weaker features in the figure. (Right) An HI spectrum through the center of the small cloud at $l \sim 187^\circ$.

ments of Zeeman splitting in the 21-cm line are essentially impossible (Heiles & Troland 2004). However, for these isolated, well-defined features the sidelobe issue is easily solvable because it's only the near-in sidelobes that matter.

The Arecibo telescope is uniquely suited for these measurements because the structures require high angular resolution together with high surface brightness sensitivity. This combination is provided only by a filled aperture. Even with Arecibo's sensitivity, getting down to the sensitivities required for measuring typical field strengths (a few microGauss) require integration times of 10 to 20 hours for each position. We intend to pursue the understanding of the magnetic field in these astronomically important dynamic structures by pushing to high sensitivity in a statistically significant sample of structures; this will take thousands of hours of Arecibo time.

3. REFERENCES

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