The Galactic HI Halo

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Abstract. We find indications for diffuse HI gas at substantial z heights in our Galaxy, with a velocity dispersion of 60 $\mathrm{km\,s^{-1}}$ and a vertical projected column density of $1.4{\cdot}10^{19}$ $\mathrm{cm^{-2}}$. This pervasive component of the emission spectrum could be identified in the Leiden/Dwingeloo 21 cm Survey (LDS) after increasing the accuracy further by correcting the observations for reflections from ground. Assuming hydrostatic equilibrium an exponential scale height of 4.4 kpc for the observed diffuse high-dispersion HI component is deduced. This differs from the scale height of 1 kpc derived by Lockman & Gehman (1991), which corresponds to a velocity dispersion of 34 $\mathrm{km\,s^{-1}}$, based on an analysis of the the Bell Laboratories HI Survey (BLS). A comparison of BLS and LDS data explains the differences in the derived model parameters in terms of baseline uncertainties at a level of $\approx$ 30 mK. We find additional indications for baseline uncertainties in the BLS data. Concerning the LDS we cannot, however, exclude that this survey may also be affected by baseline uncertainties. Receiver bandpass and stray-radiation effects need a more thorough analysis before drawing firm conclusions.

1 The Bell Laboratories HI Survey (BLS)

This survey (Stark et al. 1992) is based on observations with the 20-foot horn reflector at AT&T Bell Laboratories. This antenna has the advantage of very low sidelobe contamination due to its main beam efficiency of 92%. The width of the main beam is $2^\circ \times 2.^\circ8$ at FWHM. The average rms noise is 17 mK in 5.2 $\mathrm{km\,s^{-1}}$ wide channels. Using the BLS, Kulkarni & Fich (1985) found evidence for HI gas with dispersions of up to 35 $\mathrm{km\,s^{-1}}$. Lockman & Gehman (1991, hereafter LG) proposed that such components may be interpreted as emission from neutral gas in hydrostatic equilibrium with the gravitational potential of our Galaxy. Due to its turbulent pressure such HI gas would extend to z distances of $\approx$ 1 kpc, thus contributing a neutral component to the gaseous halo.

2 The Leiden/Dwingeloo HI Survey (LDS)

The LDS (Hartmann 1994; Hartmann & Burton 1997) is the first large scale 21 cm line survey which has been corrected for stray-radiation from the side-

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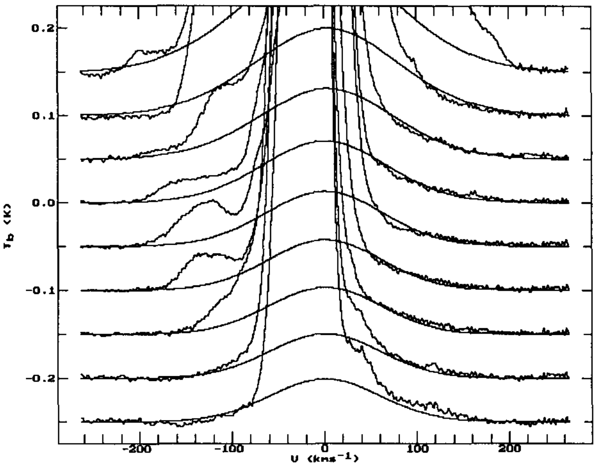

Fig. 1. Profiles averaged over all Galactic longitudes and 10° in latitude. The bottom profile is centered at latitude 85°, the top one at latitude 5°. The solid lines are not results of Gaussian decomposition, but follow from the model.

and backlobes of the antenna pattern (Hartmann et al. 1996). The width of the main beam is 0.°6 at FWHM; the average rms noise is 70 mK at a resolution of 1 $\mathrm{km\,s^{-1}}$. The LDS covers velocities between $-450 < V_{\mathrm{LSR}} < 400$ $\mathrm{km\,s^{-1}}$. We searched the LDS for low-surface-brightness features. In our analysis we first averaged spectra over large areas. After Hanning smoothing we verified that the noise went down as expected. We then determined that ground reflections limit the accuracy of the averaged profiles. Based on 2700 spectra showing the typical signature of reflections, a proper correction for such reflections from the ground was calculated. This additional correction was applied to the entire LDS data set. To make sure that the extended wings are due to smooth emission and not to a superposition of some scattered high-velocity clouds or to interference, we carefully monitored the quality of the profiles used. While averaging over 10° × 10° we simultaneously calculated the variance of the line emission for each velocity channel. Multiple observations at the same position were compared. Averaged spectra at ~250 different positions were decomposed into Gaussian components. Only those channels of the averaged spectra which were found not to be contaminated by fluctuations (due to small scale structures like HVCs or interference) have been used for the fit. Thus the analysis was most sensitive to extended HI components. To verify that these lines are not due to residual stray radiation we applied a similar Gaussian analysis to the observed stray-radiation components. We found that the velocity dispersion of the stray components is low compared to the large velocity dispersion (LVD) component. We conclude that the outermost profile wings cannot be due to stray radiation. HI lines with LVD

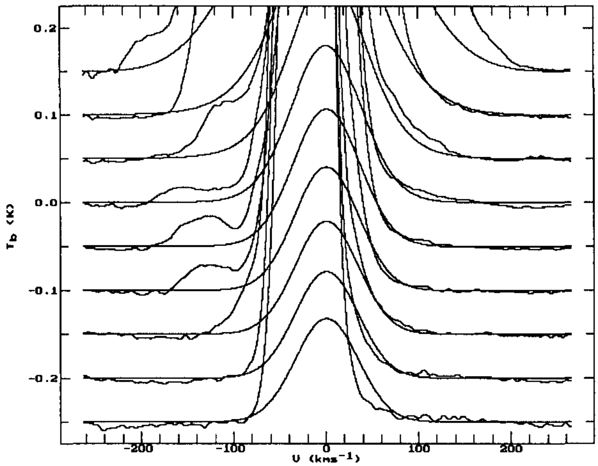

Fig. 2. Profiles averaged over all Galactic longitudes as in Fig. 1, but derived from the BLS. The solid lines represents the Lockman layer (LG model 2).

were found in all of the averaged spectra. The mean velocity dispersion of these lines is $\sigma = 60(\pm 3)\mathrm{km\,s^{-1}}$ at the north galactic pole and increases toward lower latitudes, consistent with line broadening due to Kolmogoroff turbulence along the line of sight which increases toward lower Galactic latitude. Based on the hypothesis of hydrostatic equilibrium as proposed by LG, we modelled the HI emission for all latitudes $b > 0°$. Our model is based on the observed velocity dispersion of 60 $\mathrm{km\,s^{-1}}$ and a column density of $N_{\mathrm{HI}} = 1.4 \cdot 10^{19}$ cm^{-2} in the direction of the north galactic pole. Fig. 1 shows the LDS H I emission averaged over all longitudes and 10° in latitude. In Fig. 2 we show for comparison the BLS H I emission and the emission modelled according to LG. The basic parameters in this case are the velocity dispersion of 34 $\mathrm{km\,s^{-1}}$ and the column density of $N_{\mathrm{HI}} = 1.9 \cdot 10^{19}$ cm^{-2}.

3 Discussion

From the comparison of Figs. 1 and 2 it is obvious that both data sets and the corresponding models differ with respect to the profile wings. Smoothly varying offsets suggesting baseline problems are visible. To study whether one of the surveys may be affected by systematic baseline problems we averaged, for both surveys, fields of 5° × 5° in size. We found in the majority of cases significant baseline deviations between the averaged BLS and LDS profiles. Fig. 3 displays a typical case. The BLS profile is found to be consistent with the LDS data after applying a second-order baseline correction to the BLS profile. There is no indication for any residual stray radiation contamination. While

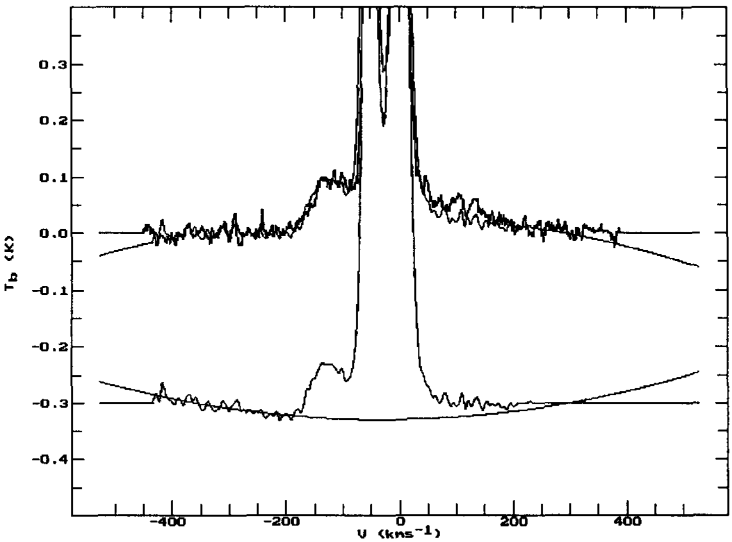

Fig. 3. Intercomparison of LDS and BLS profiles centered at $(l, b) = (142\overset{\circ}{.}5, 42\overset{\circ}{.}5)$. The lower panel was derived from the BLS. A second-order baseline readjustment for the BLS profile is indicated. The upper panel is an overlay of the corresponding LDS profile (thick line) and the readjusted BLS profile (thin line).

it is obvious from Fig. 3 that the BLS profile suffers from an ill-determined baseline we assume that the LDS data set is free from residual baseline errors. The differences in the baselines are up to 20 or 30 mK, about 50% of the amplitude of the LVD component which was determined by analyzing the LDS. It is essential to verify that the LVD components derived from the LDS are unaffected. Our attempts to improve the BLS baseline correction failed due to the fact that the number of channels which are safely assumed to be free from possible H I emission are usually limited. A reanalysis of the LDS with the aim to get an improved insight to the baseline accuracy is in progress.

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