ev. Mexicana Astron. Astrof., 21, 273-277 (1990)

DISTRIBUTION OF THE ATOMIC COMPONENT IN THE LOCAL INTERSTELLAR MEDIUM. 1) THE WARM NEUTRAL INTERCLOUD MEDIUM (WNM).

W. G. L. Pöppel, P. Marronetti, P. Benaglia.
Instituto Argentino de Radioastronomía

RESUMEN : Se usaron dos extensos atlas de perfiles de la linea de 21 cm del HI para estudiar la componente tibia neutra del medio interestelar. El método se basa en el análisis gaussiano de las contribuciones de dicha componente a la emisión en los perfiles. Los principales resultados están resumidos en las Figuras 1 y 2 que dan las respectivas distribuciones de la densidad de columna N_H y de la velocidad radial V en función de la posición l, b.

ABSTRACT : Two atlas of profiles of 21-cm have been used for computing the HI-emission due to the WNM (Heiles & Habing 1974 and Colomb, Pöppel and Heiles 1980). The method is based on a Gaussian approximation of the contributions of the WNM to the profiles. The main results are summarized here in the form of two maps showing the distributions of N_H and of the radial velocity respectively as a function of l and b (Figs. 1 and 2).

Key words: INTERSTELLAR-CLOUDS — INTERSTELLAR-GENERAL — GALAXY-STRUCTURE

. INTRODUCTION.

In this paper we make a global study of the kinematics and the distribution f the warm neutral intercloud medium (WNM) for the whole sky at $|b| \geq 10°$-$0°$. For this purpose we use both the HI-atlas by Heiles and Habing (1974), nd the one by Colomb, Pöppel and Heiles (1980). Both together form a very arge homogeneous data set obtained with a beamwidth of $\simeq 0.5°$- $0.6°$ and a elocity resolution of $\simeq$ 2 km/s. As the paper will be published elsewhere in etail, here we present only some of the main results. In a forthcoming paper e shall analyze also the cool neutral component of the local HI.

Since the optical depth of the WNM is very low, its contribution to a 21-cm ine can be approximated by a Gaussian component, at least for galactic atitudes b being not too low (cf. Radhakrishnan et al. 1972, Mebold 1972). omputations by Olano show that the emission due to the WNM can be well pproximated by Gaussian curves for $|b| \geq 10°$ (Pöppel et al. 1982). In spite f the difficulties which are intrinsical to a Gaussian analysis (cf. Cappa e Nicolau and Pöppel 1986), we think that it can give us a good qualitative nsight into the overall distribution and kinematics of the WNM, provided hat its spatial distribution is not very irregular along the line of sight.

There are two effects however, that could distort the results largely, amely, I) absorption and blending effects due to very cold gas layers and, I) spurious contributions due to stray radiation.

We have intended to diminish the first effect at large scale by considering nly $|b| \geq 10°$. The second effect can be quite disturbing for a study of low ignals (cf. van Woerden 1962, Kalberla et al. 1980). We shall return to this elow.

II. METHOD.

The computational method suited for our Gaussian analysis assumes that the WNM has a continuous distribution on sky, its parameters varying smoothly with position. These are the amplitude T, the central velocity V, and the velocity dispersion σ. For $|b| < 60^\circ$ we considered cells at intervals of 10° in l, b, each one being $5^\circ \times 4^\circ$ wide in l, b. For $|b| \geq 60^\circ$ the intervals in l were of 20° and the cells were $10^\circ \times 4^\circ$ wide. In addition we considered about 30 cells of latitudes $b = +25^\circ$ and $b = +35^\circ$. Both polar caps have been also considered. The values $|b| = 10^\circ$ were mostly excluded because of the considerable blending due to the cold clouds at these latitudes. It is assumed that the WNM does not present important variations within a given cell.

The selection of the most adequate Gaussian curve for approximating the WNM within a given cell has been made by computing the Gaussian curve which best fits the whole set of profiles within that cell. The fitting method is a least squares algorithm, applied to a sequence of Gaussian curves defined by varying the parameters within given intervals. For each profile the differences with the Gaussian curve are evaluated avoiding the intervals where there are other (narrow) components present or the Gaussian wings are below the noise.

The number of profiles per cell varied from a few at $|b| \simeq 80^\circ$ to more than 200 at lower $|b|$. The quality of the fitting was checked through visual inspection of the results in a screen terminal by sampling the profiles of the cell (about 10%) and computing the corresponding residual profiles.

The method worked quite satisfactory in most of the cases. At those cells where blending with narrow components was large, the method did not converge. Therefore a " visual " method was tryed by inspecting the residual profiles in the screen terminal. When this did not work the cell was left " blank ".

We considered 436 cells from which 320 were analyzed by the least squares fitting program, 77 visually and 39 were left blank. About 20 cells in the northern sky had a very low signal, with an area under the curve below 38 K.km/s, which we fixed as our sensitivity limit. They correspond to real holes in the distribution of the WNM on the sky. After checking all the results on the screen as mentioned above, it was found that the least squares fitting could be considered as quite good in 89% of the cases, and satisfactory for the rest.

The total number of the profiles included in our analysis was 32.191 (about 17% of all of the avalaible profiles). It is rather difficult to estimate the errors of the fitting method. The accuracy of the parameters found is simply given by the size of the spacements ΔT, ΔV and $\Delta\sigma$ employed. We used $\Delta T = 0.5$ K and $\Delta V = \Delta\sigma = 1$ km/s. The real size of the errors in the Gaussian fitting is produced by quite different and uncontrollable effects, like contribution of stray radiation and blending by cool gas. For further details about the computational method we refer to Marronetti (1989).

III. RESULTS AND CONCLUSIONS.

The results of our analysis of the WNM are summarized here in the form of two maps namely, one showing the distribution of the column density N_H (Fig 1), and the other one showing that of the radial velocity V (Fig 2), both as a function of galactic coordinates l, b. The map of V has been linearly smoothed by averaging the values over areas of about $10^\circ \times 10^\circ$.

Regarding the overall structure of the WNM several general conclusions are apparent from these maps. It is important to remark that, unlike previous papers which did not separate the cool component from the warm one when nalyzing the overall structure of the low-velocity HI, our results apply to he WNM **separately**, since the cool one has rather different properties.

From Fig.1 it is apparent that the distribution of N_H is not symmetric with espect to the galactic plane. Definitely higher values of N_H are found in he southern hemisphere than in the northern one (cf. Cleary et al. 1979). lthough there is a trend for stratification of the WNM at $|b| \leq 40°$, it eems clear that its general distribution is quite irregular, thus, implying arge deviations from the cosec b-law (Fejes and Wesselius 1973). At lower atitudes ($|b| \simeq 10°-20°$) several intense clumps can be distinguished, hich probably arise from more distant features located near the galactic lane.

In the northern hemisphere an absolute hole in the distribution of the WNM s apparent. It is centered near $l \simeq 150°$, $b \simeq 70°$ (cf. Wesselius and Fejes 973) having a diameter of about 40°. In the southern hemisphere there are wo minima. The larger one , being rather irregular, is centered at $l \simeq 0°$, b $-65°$ with a diameter of about 40°. The other one, of elongated shape, is entered at $l \simeq 240°$, $b \simeq -55°$ (cf. Cleary et al. 1979).

A remarkable fact is that the northern pole of the Gould's belt (i.e. $l \simeq$ 05°, $b \simeq 72°$, according to Stothers and Frogel 1974) is located within the orthern hole eccentrically (cf. Wesselius and Fejes 1973), while the outhern pole falls just within the larger southern minimum.

A comparison of Fig. 1 with the whole-sky maps of the continuum intensity t 150 MHz (Landecker and Wielebinski 1970) and 200 MHz (Dröge and Priester 956) reveals some striking correlations. Examples are the counterparts in ig. 1 of the North Polar Spur (Loop I) as well as of the northern and the outhern minima of the continuum, although their centers in Fig. 1 appear omewhat displaced toward higher latitudes.

In Fig. 1 there seem to be also correlations with the more prominent arcs f Loop III at $l \simeq 100°$ and $l \simeq 160°$, both at $b \simeq 20°-40°$ (cf. also Heiles nd Jenkins 1976 and Cleary et al. 1979), and Loop IV (cf. Fejes 1971) at $l \simeq$ 90°, $b \simeq 30°-60°$, as defined in the maps of the continuum at 820 MHz by erkhuijsen et al. (1971).

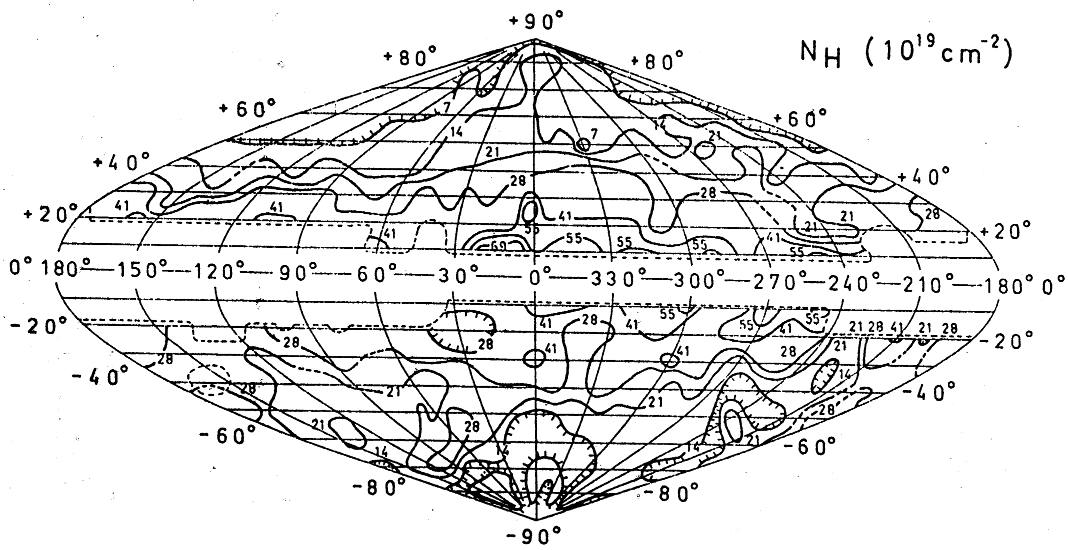

Fig. 1. Distribution of N_H.

On the other hand, it is well-known that the total neutral hydrogen column density is roughly anticorrelated with the observed intensity of the soft X-ray diffuse background at energies lower than 0.28 keV (cf. McCammon et al. 1983). A comparison of Fig. 1 with the B and C-band maps of McCammon et al. (1983) shows a correspondence between several soft X-ray features of large intensity and low intensity regions of the WNM.

From Fig. 2 we see that at low latitudes (say at $|b| \leq 30^\circ$), the kinematics of the WNM is roughly consistent with simple galactic differential rotation. Important deviations are evident however, the most notorious being the distortions of the lines of nodes (V = 0).

At higher latitudes (say at $|b| \geq 50^\circ$), the velocities are all negative, thus implying a general fall of the WNM toward the galactic plane (cf. Cleary et al. 1979 and the papers mentioned there).

Now we come back to the influence of stray radiation on the observations. Heiles et al. (1981) analyzed the mean error introduced by stray radiation in the Heiles and Habing (1974) survey. They have shown that the total integrated N_{HI} could become 100% too large at their minima at high positive latitudes due to stray radiation. Thus, in particular the boundaries of the hole in Fig. 1 could vary (increase) somewhat. Analogously, the southern observations made with the antenna of the IAR, which had a short dipole at its focus, are also known to be affected by stray radiation. Thus our results (Figs. 1 and 2) should be treated with some caution. The fact, however, that our conclusions are well consistent with former results seems to be a good argument for thinking that stray radiation is not distorting our results very much.

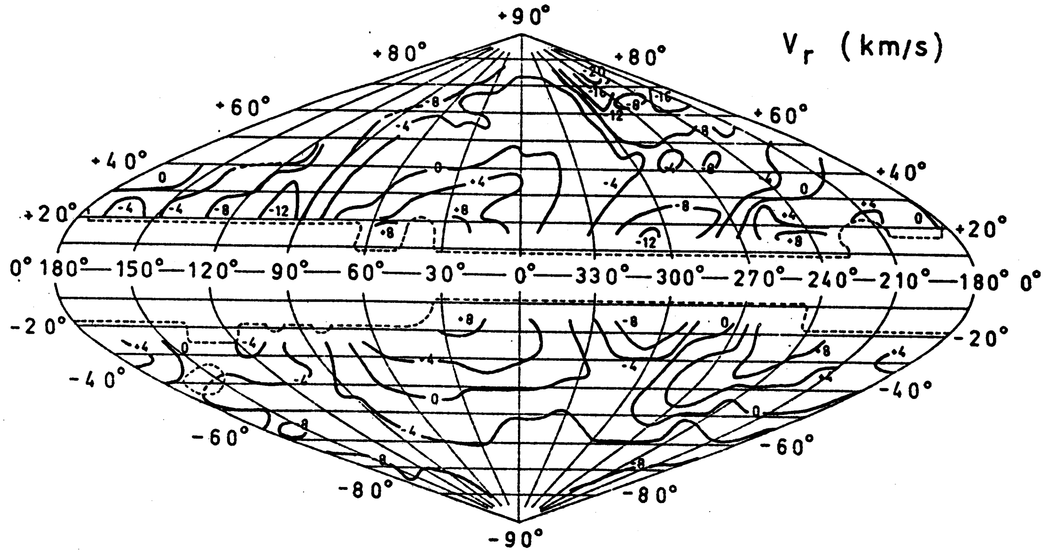

Fig. 2. Kinematics of the WNM.

As a further argument, in Fig. 3 we show the distribution of the mean values of the velocity dispersion σ found for our Gaussian approximations of the WNM. As can be seen, in general σ is increasing when $|b|$ decreases, as is consequent with an increasing of broadening effects by galactic differential rotation due to the enlarging of the sampled intervals of distances.

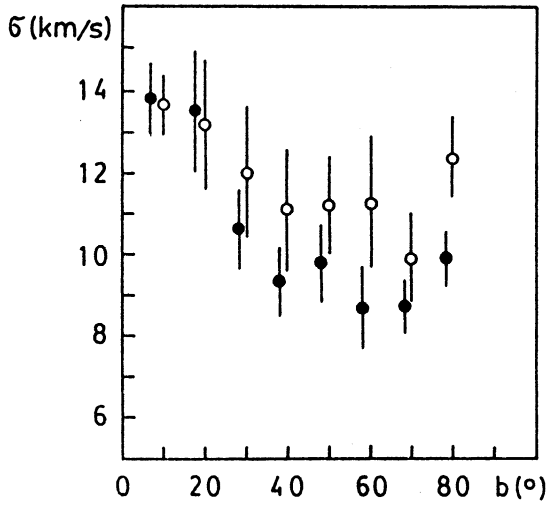

Fig. 3. Distribution of mean nucleus of the velocity dispersion.

EFERENCES.

erkhuijsen,E.M., Haslam,C.G.T., Salter,C.J.: 1971. Astron. Astrophys. 14, 252.
appa de Nicolau,C.E., Pöppel,W.G.L.: 1986. Astron. Astrophys. 164,274.
leary,M. , Heiles,C., Haslam,C.G.T.: 1979, Astron. Astrophys. Suppl. 36, 95.
olomb,F.R., Pöppel,W.G.L., Heiles,C.: 1980, Astron. Astrophys. Suppl. 40,47.
röge,F., Priester,W.: 1956. Z. Astrophysik 40,236.
eies,I.: 1971, Astron. Astrophys. 15, 419.
eies,I., Wesselius,P.R.: 1973. Astron. Astrophys. 24, 1.
eiles,C., Habing,H.J.: 1974. Astron. Astrophys. Suppl. 14, 1.
eiles,C., Jenkins,E.B.: 1976, Astron. Astrophys.. 46. 333.
eiles,C., Stark,A.A., Kulkarni,S.: 1981. Astrophs. J. 247. L73.
alberla,P.M.W., Mebold,U., Reich,W.: 1980, Astron. Astrophys. 82. 275.
andecker.T.L., Wielebinski,R.: 1970, Austral J. Phys. Suppl. 16.
arronetti.P.: 1989, Tesis de Lic. en Física, University of Buenos Aires.
cCammon,D., Burrows,D.N., Sanders,W.T., Kraushaar,W.L.: 1983. Astrophys. J. 269, 107.
ebold,U.: 1972, Astron. Astrophys. 19, 13.
öppel,W.G.L., Olano,C.A., Cappa de Nicolau,C.E.: 1982. Rev. Mex. Astron. Astrof. 5, 223.
adhakrishnan,V., Murray,J.D., Lockhardt,P., Whittle,R.P.J.: 1972.Astrophys. J. Suppl. 24, 15.
tothers,R., Frogel,J.A.: 1972, Astron. J. 79, 456.
an Woerden,H.: 1962, Proefschift, University of Leiden.
esselius,P.R., Fejes,I.: 1973, Astron. Astrophys. 24, 15.

aula Benaglia, Pedro Marronetti, Wolfgang Pöppel: Instituto Argentino de Radioastronomia, Casilla de Correo 5, 1894 Villa Elisa, B.A., Argentina.