PAPER 6

THE DISTRIBUTION OF ATOMIC HYDROGEN IN THE INNER PARTS OF THE GALAXY

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The determination of the distribution of hydrogen from 21-cm. observations in parts of the Galaxy, which are nearer to the centre than the sun, is seriously handicapped by the fact that the observed radial velocity of the hydrogen clouds determines only the distance to the galactic centre. So two possible values of the distance to the sun correspond to one value of the frequency. We have used as a criterion to separate the contributions from the two regions the latitude distribution of the radiation.

About 200 drift curves, with paraboloid and frequency fixed, were obtained with the Kootwijk receiver at frequency intervals of about 40 kc./s. at longitudes $l=340°$, $345°$, ..., $35°$. Further, line profiles are available in this region at $2\frac{1}{2}°$ longitude intervals from a survey supervised by C. A. Muller and G. Westerhout. The profiles at latitudes $+\frac{1}{2}°$, $-1\frac{1}{2}°$, $-3\frac{1}{2}°$ were used in the present investigation. Finally, some preliminary measurements of the continuous radiation at about 21-cm. wave-length were used. Ohlsson's pole at $12^h\ 40^m$, $+28°$ was used in all reductions.

All the drift curves and line profiles were corrected for the effects of antenna pattern and band-width of the receiver.

To explain the remaining part of the reductions we shall first assume that the effects of the continuous radiation and the dispersion of cloud velocities may be neglected. We may then convert all the intensities into optical depths. For the separation of the contributions from every two corresponding points on the line of sight we need the linear distribution of hydrogen perpendicular to the galactic plane. This may be obtained from frequencies for which the two contributing points are close together or coincident, i.e. from frequencies near the maximum frequency. The distance for these frequencies is known and the latitude distribution may be converted to a linear distribution vertical to the galactic plane. This may be done for all longitudes so that the vertical distribution can be studied over a range of distances from the galactic centre. Now the separations may be carried out. For each longitude and frequency the optical depth is read at four or more different latitudes. The longitude and frequency determines, with the known curve of rotational velocities, the distances of the contributing points.

Therefore the vertical linear distribution, determined before, may be converted to a latitude distribution at each of the two contributing points. The latitudes of the centres of the distributions as well as the corresponding maximum optical depths are unknown. Each of the optical depths read at four different latitudes may now be expressed as a sum of two contributions, each of which involves the known latitude distribution, an unknown mean latitude and an unknown maximum optical depth. The four unknowns may be solved from these equations. The separation has then been carried out.

However, as mentioned before, the effects of the continuous radiation and the peculiar cloud velocities has been neglected here. The effect of the continuous radiation is difficult to deal with, since it depends on the yet unknown hydrogen densities. The difficulty was solved by a preliminary separation, carried out in intensities instead of in optical depths. The four equations then include the intensity of the continuous radiation originating from behind the hydrogen region considered. These intensities were obtained from a model of the space distribution of continuous galactic radiation. The solution of the four equations mentioned before, then yielded a preliminary model of the distribution of hydrogen. This model was used only to give the conversion of measured intensities into optical depths.

A further difficulty is formed by the peculiar cloud velocities. The study of the vertical distribution indicates that the thickness of the gas layer between the points of half the maximum density is about 220 parsecs throughout the inner parts of the Galaxy. Now the general mass density and, therefore, the vertical force will increase towards the centre. This implies an increase in peculiar velocities which undoubtedly will not be restricted to the vertical components of the peculiar velocities. From an unpublished model of the distribution of mass in the Galaxy the rate of increase of the dispersion of cloud velocities was estimated. The values of the average cloud velocities used are given in Table 1. All measurements were then corrected for the effect of peculiar cloud velocities.

The final reduction proceeds as in the simplified case described above. The resulting relative distribution of hydrogen vertical to the galactic plane is given in Fig. 1. It does not seem to depend on the distance from the galactic centre. The distance between half-density points is 220 parsecs.

The mean latitudes resulting from the separations may be converted into vertical distances or heights z. These values were smoothed in rings of constant distance to the galactic centre. The smoothed values $\bar{z}$ are shown in Fig. 2. The separations were now carried out again with the smoothed z values, and the optical depths re-determined. These were reduced to hydrogen densities, which are plotted in Fig. 4 of paper 5. It is seen at

Table 1. *The assumed run of the average peculiar cloud velocity η with distance R from the galactic centre*

R	2	3	4	5	6	7	8·2	kiloparsecs
η	14·8	11·6	9·5	8·1	6·9	6·0	5·0	km./sec.

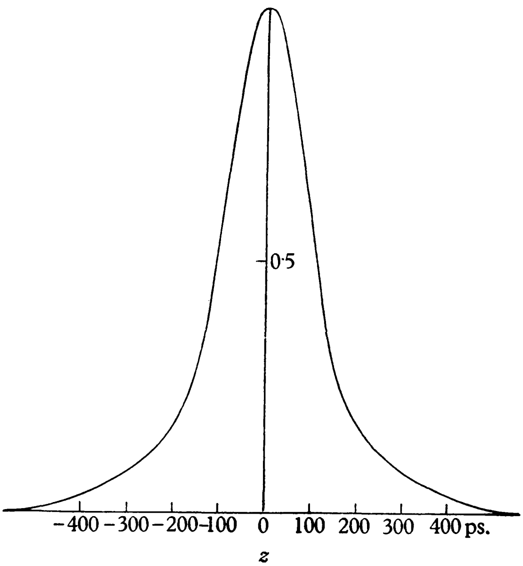

Fig. 1. The relative distribution of hydrogen density perpendicular to the galactic plane.

once that the hydrogen is concentrated in arms, as it is in the outer parts of the Galaxy. The Orion arm appears at $l=40°$ at 4·5 kiloparsecs distance and may be followed to the other side of the Galaxy, except for a break near $l=30°$. The next arm is the Sagittarius arm. It runs near the sun about 1·5 kiloparsecs inside the sun's circle and there contains the O-associations of Morgan, Code and Whitford (1953) [1]. It may also be followed to the other side of the Galaxy. There the structures of both this arm and the Orion arm seem to become very complicated, however. Further arms or parts thereof may be noted; they are tangential to the line of sight at $l=6°$, $l=359°$ and perhaps at $l=346°$.

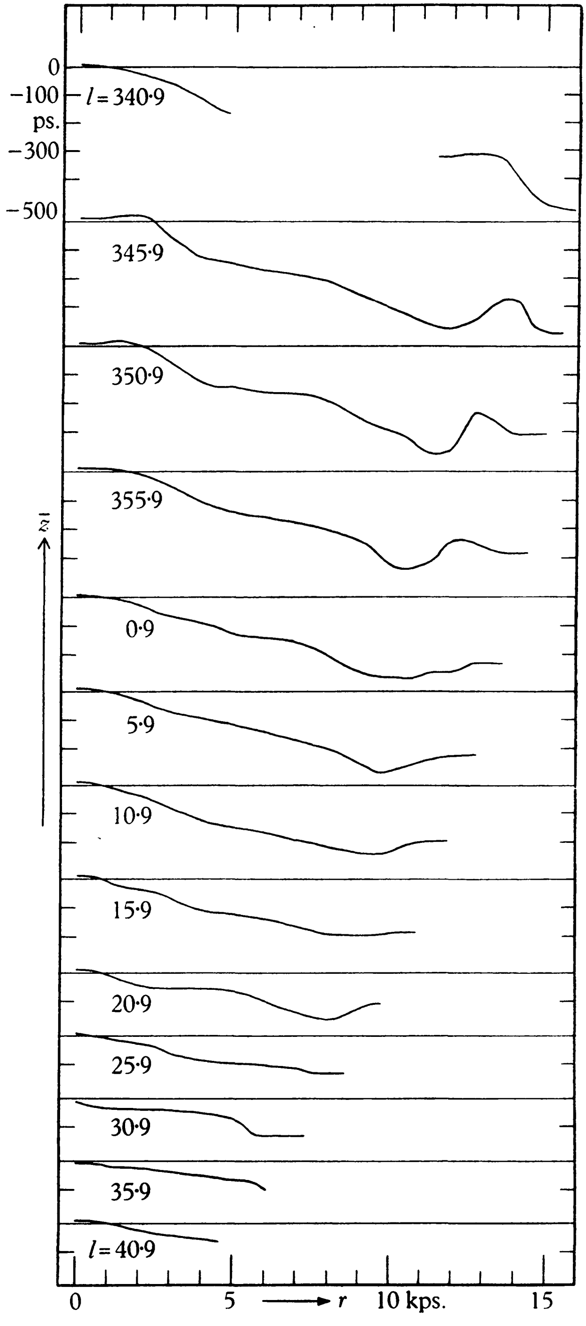

Fig. 2. The mean heights $\bar{z}$ of hydrogen above Ohlsson's galactic plane as function of distance r for different longitudes.

The Sagittarius arm, the arm at $l = 6°$ and the possible arm at $l = 346°$ fit well with the secondary maxima in the rotational velocities found by Kwee, Muller and Westerhout (1954) [2].

Both the Orion arm and the Sagittarius arm are seen to be inclined in the sense that they are trailing.

A detailed account of this investigation has been published in *B.A.N.* no. 475 [3].

REFERENCES

[1] Morgan, W. W., Code, A. D. and Whitford, A. E. *Ap. J.* **118**, 318, 1953.
[2] Kwee, K. K., Muller, C. A. and Westerhout, G. *B.A.N.* **12**, 211, no. 458, 1954.
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Discussion

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