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A STUDY OF NEUTRAL HYDROGEN IN THE SOLAR NEIGHBOURHOOD OF THE MILKY WAY

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Summary

The distribution of neutral hydrogen away from the galactic plane has been measured between Dec. = +90° and Dec. = −32°. It shows a number of neutral hydrogen clouds which coincide in position with dust complexes. The major feature of the distribution is the excess of neutral hydrogen in the position of the local system (Gould's Belt) of early-type stars and dust. The system ($\sim 10^5 M\odot$) appears to represent a later formation in the local spiral arm. An extended region in Cepheus is probably similar.

1. *Introduction.*—Gould (**1**) noted that the brighter naked-eye stars of the northern and southern Milky Way formed a belt inclined at an angle of 20° to the galactic plane. Shapley (**2**) found this belt of stars to be a sub-system of the Galaxy localized within several hundred parsecs of the Sun. The B stars within 200 parsecs of the Sun have the spatial distribution shown in Fig. 1 with a semi-amplitude of 12°. These stars are mainly responsible for the naked-eye Gould Belt. Bright Be stars of magnitude less than 6·5 show the same distribution. Some constituents of the interstellar medium, notably reflection nebulae which are plotted in Fig. 1, also indicate a system inclined at about 20° to the galactic plane (**3**). These facts suggest that there is a galactic sub-system within which the Sun lies having the properties summarized in the following table (**4**, **5**)

Table I

Properties of the Local System

N. Pole	$l' = 170°$	$b' = +74°$
Centre	$l' = 240°$	$b' = -3°$
Radius	~500 parsecs	
Mass	$\sim 10^8 M\odot$?	

The reality of this proposed sub-system has been questioned (e.g. **4**, **3**); it may be the observational effect of a dust density which falls at increasing distances or it may be the effect of a fortuitous irregular distribution of stars.

Strong new arguments in favour of the reality of a local system can be derived from the neutral hydrogen distribution away from the galactic plane. Lilley and Heeschen (**6**) have noted a correlation between neutral hydrogen gas and dust in the southern parts of the sub-system. A preliminary investigation of Jodrell Bank hydrogen-line records showed a much more extensive correlation between the neutral hydrogen distribution and the local system (**7**).

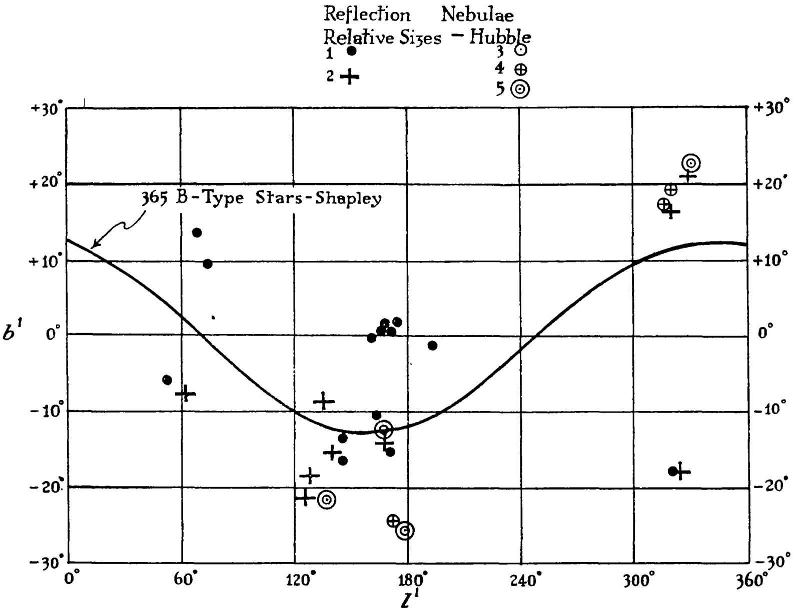

FIG. 1.—*The full-line represents in galactic coordinates the best fitting plane drawn through the bright B stars (after Shapley). The positions of large reflection nebulae (after Hubble) are also shown.*

2. *Programme of observations.*—During the course of the hydrogen-line programme of the 30 ft paraboloid (beamwidth $1^{\circ}\cdot5 \times 1^{\circ}\cdot7$) in 1955 and 1956 a large number of drift curves at constant frequency were taken at various declinations. These employed bandwidths of either 18 Kc/s or 40 Kc/s and showed a clear separation from the galactic plane of a broad feature centred about 20° away from the plane.

The preliminary analysis of this data and of Muller and Westerhout's (**8**) spectra taken near the galactic plane pointed to the desirability of a complete spectral survey of the sky visible from Jodrell Bank. This complementary survey consisted of setting the 30 ft paraboloid at various declination settings 5° apart and allowing the rotation of the Earth to sweep the beam through 24 hours in right ascension. During each drift the hydrogen comparison radiometer was constantly sweeping a frequency band 1·2 Mc/s in width so that spectra were obtained at least every 5° in the sky. The observing bandwidth was 100 Kc/s; this was adequate to measure the line integral of neutral hydrogen at each point. Each declination run was repeated. The survey covered declinations −32° to +90°. In all, 2500 spectra were taken and analysed.

The velocity characteristics of the neutral hydrogen in the local sub-system well away from the galactic plane were investigated by taking narrow-band spectra in sample regions. Bandwidths of 100, 25 and 3·5 Kc/s were used simultaneously; the 25 Kc/s channel gave the spectra required while the 3·5 Kc/s channel was used as a check to show that the 25 Kc/s channel produced no broadening in the observed profiles.

3. *Analysis and results*

(i) *Drift curves at a single frequency.*—In certain regions of the sky a drift curve across the galactic plane did not show a single broad peak but a broad peak centred on the radio galactic plane with a second fainter peak sometimes as much as 20° in galactic latitude from the first. Such constant declination drift curves

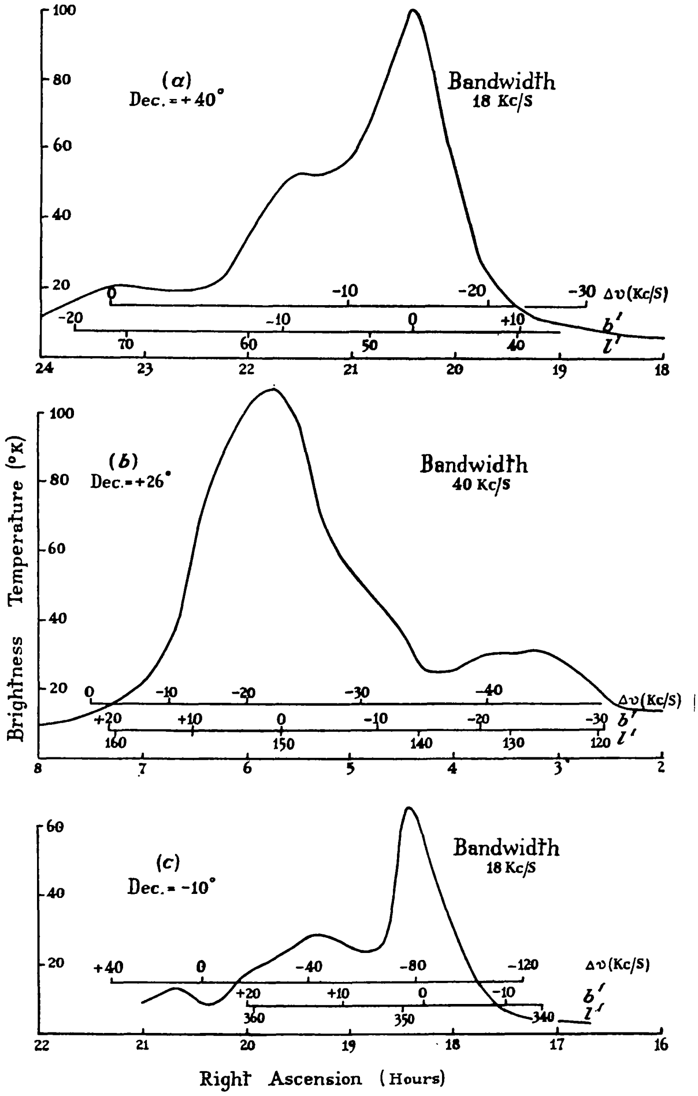

FIG. 2.—*Constant frequency drift curves across the galactic plane and the local system at* (*a*) *Dec.* = 40°, (*b*) *Dec.* = 26°, (*c*) *Dec.* = −10°. *Galactic coordinates and the frequency difference* $\Delta\nu$ *from the l.s.r. are given.*

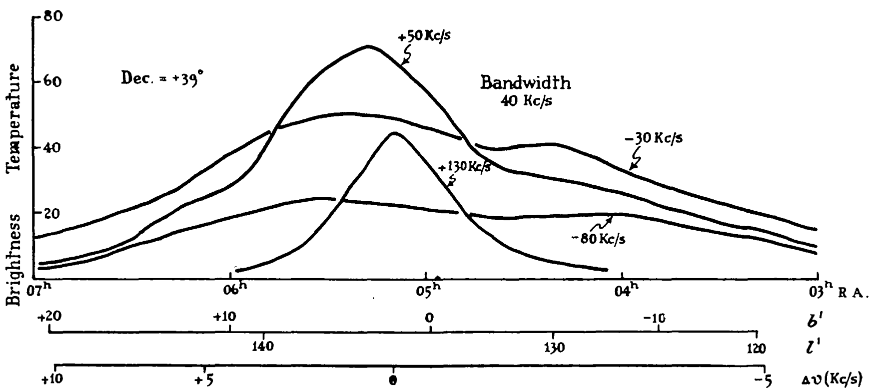

FIG. 3.—*Drift curves across the galactic plane and the local system at Dec.* = 39° *for various frequencies relative to the l.s.r.*

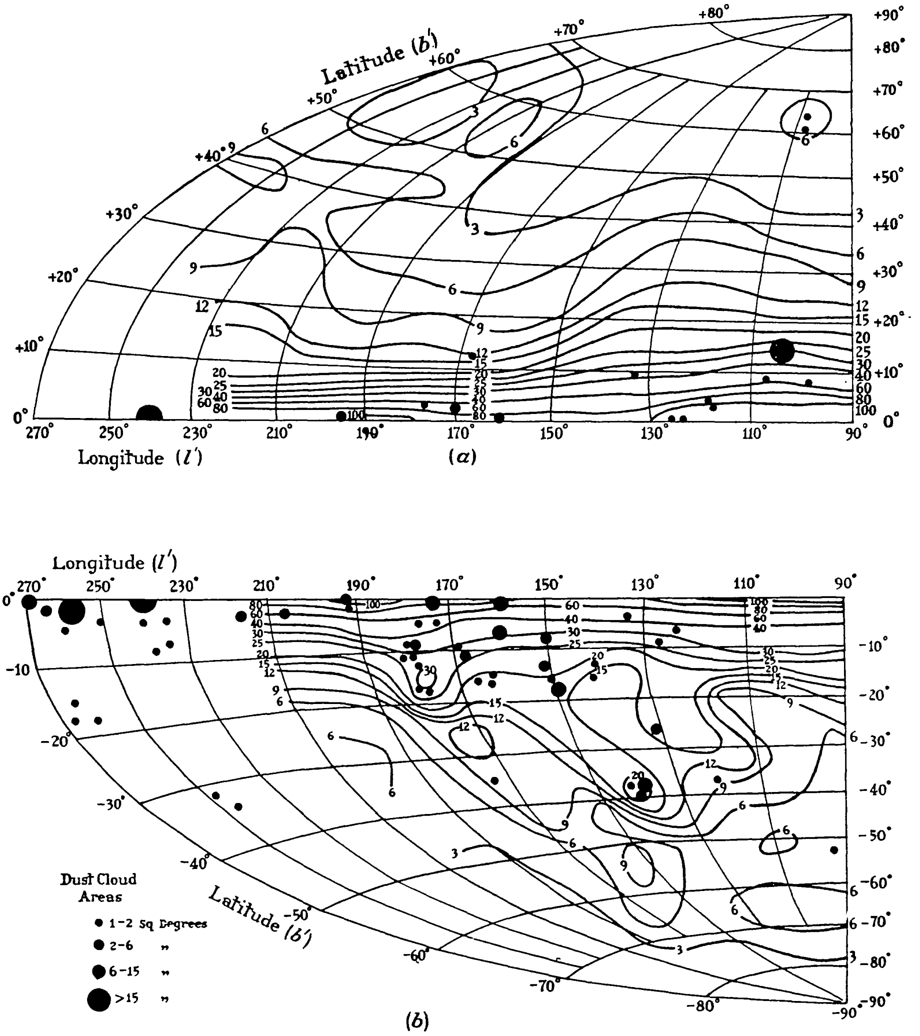

FIG. 4.—*The distribution of N (the integrated number of neutral hydrogen atoms per cm^2 in the line of sight) for the northern sky in units of* 10^{20} *cm^{-2}.*

taken at frequencies near the local standard of rest (l.s.r.) are shown in Fig. 2. The ordinates are brightness temperature while the abscissae show, as well as the right ascension, the galactic coordinates (l', b') and the changing frequency $\Delta\nu$ (although constant relative to the Earth) relative to the local standard of rest in the solar neighbourhood of the Galaxy. Fig. 2 (*a*) is a drift curve across the Cygnus region and shows a strong asymmetry south of the plane lying between galactic latitudes $-5°$ and $-15°$. Fig. 2 (*b*) in the Taurus region gives a clear separation between the main galactic peak and the neutral hydrogen belt at latitudes $-15°$ to $-30°$. A similar separation is visible above the plane in the Ophiuchus–Scorpio region shown in Fig. 2 (*c*).

Hydrogen at different distances can be distinguished due to galactic rotation by taking drift curves at different frequencies. This criterion still applies in the anticentre region where galactic rotation is nearly perpendicular to the line of sight. Such a series of drift curves at different frequencies was taken at Dec. $= 39°$ and the results are shown in Fig. 3. The frequency relative to the local standard of rest at any right ascension for a given curve is obtained by adding the frequency

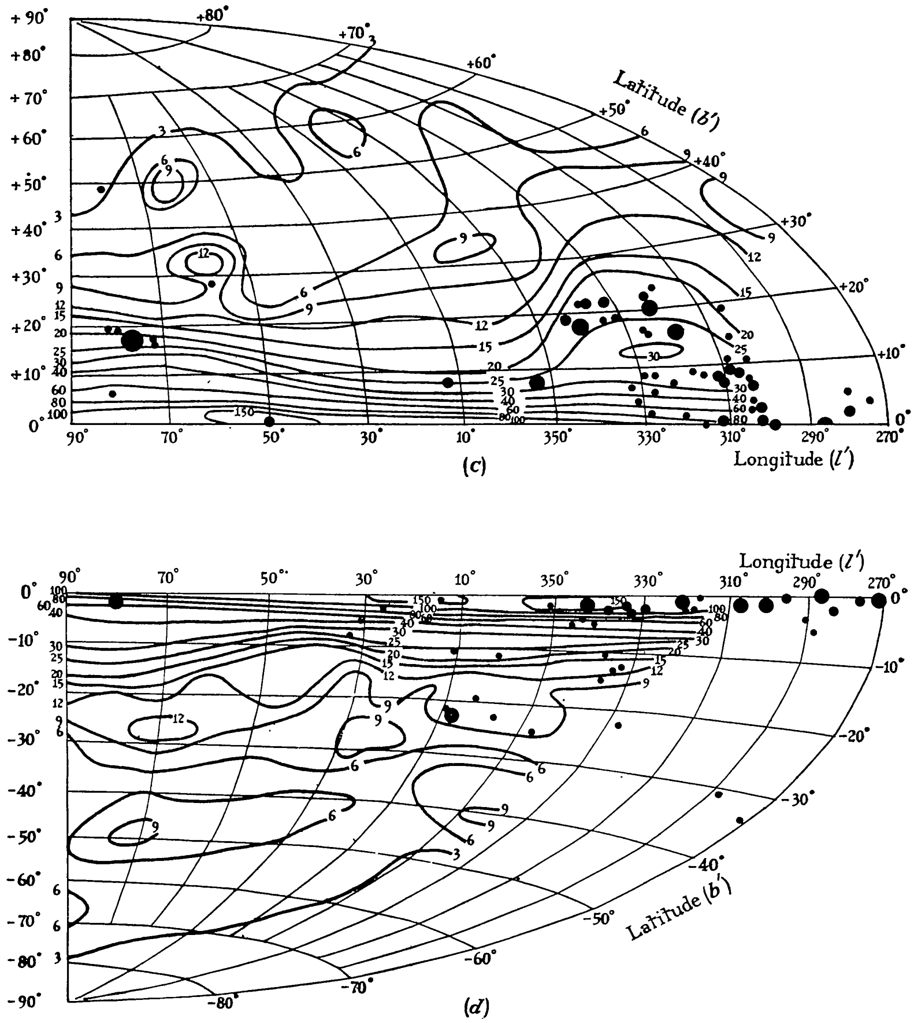

FIG. 4.—*Continued.*

correction $\Delta\nu$ at that right ascension to the frequency assigned to that curve. The H I spectrum in this region of the sky is a single line 160 Kc/s in width at the half temperature points. The drift curve for higher frequencies is narrow and consequently refers to more distant neutral hydrogen. The same phenomenon is observed in the absorption spectrum of Taurus-A (9) where absorption which occurs in nearby hydrogen is observed at the lowest frequencies. Hydrogen at negative frequencies (recession) relative to the local standard of rest has one broad peak on the galactic plane and a secondary maximum 5° to 10° below the plane. This local hydrogen some distance from the plane at zero or negative frequencies relative to the l.s.r. is visible over a range of galactic longitudes. It occurs above the plane around $l' = 330°$ and below the plane around $l' = 150°$.

(ii) *The survey of neutral hydrogen spectra in the Northern Sky.*—This survey, taken with a bandwidth of 100 Kc/s was designed to measure N, the integrated number of neutral hydrogen atoms in a 1 cm^2 column in the line of sight at each point.

$$N = \int N_H dl = 2{\cdot}3 \times 10^{15} \int \tau(v) dv$$

where N_H is the number of atoms per cm^3, l is the depth, $\tau(v)$ is the optical depth of neutral hydrogen with a velocity v cm/sec. For this evaluation the kinetic temperature of the neutral hydrogen was taken to be 125°K.

The group of spectra obtained at a given declination was analysed in the following way. The integrated quantity $\int T(v)dv$ was measured with a planimeter for each spectrum. $T(v)$ is the observed temperature on an arbitrary scale. These quantities are standardized by comparing spectra taken near the plane in the survey with similar spectra in Muller and Westerhout's (**8**) catalogue of profiles. All brightness temperature spectra were then converted into optical depth spectra and the value of N was derived for each. The value of N for the declination range $-32°$ to $+90°$ were plotted in galactic coordinates. Smooth contours were drawn through these points and the resultant map is shown in Figs. 4 (*a*), (*b*), (*c*) and (*d*). No attempt has been made to represent detail less than 5° in diameter. The units of N are 10^{20} neutral hydrogen atoms per cm^2 column in the line of sight.

This map may be compared with a map prepared by Erickson *et al.* (**10**) on a 10° grid for latitudes more than 20° from the plane. The agreement with this less detailed map, allowing for the difference in grid spacing, is good.

(iii) *Narrow band spectra.*—Spectra obtained with half-power bandwidths of 25 and 3·5 Kc/s were taken at the positions of enhanced N found away from the plane in Fig. 4; regions in the Gould Belt area were included. The central frequency, peak temperature and half-width of these profiles were compared with the same properties of profiles obtained nearby on the galactic plane which were checked against the Westerhout and Muller profiles.

Averages of three profiles taken with the 25Kc/s bandwith channel in each of eight regions away from the plane are reproduced in Fig. 5. The profiles obtained with the 3·5 Kc/s channel were not significantly different from those taken with the 25 Kc/s bandwidth. Peak brightness temperatures of up to 55°K were measured 20° off the plane along both axes of the Gould Belt system.

A number of the brightness temperature spectra show half widths to half temperature points of 7 km/sec. If the kinetic temperature is taken as 125°K the optical depth spectra indicate a value of halfwidth (η) of 5·8 km/sec. This may be compared with values of 12 to 10 km/sec for the galactic plane profiles at distances of 4 to 8·2 kiloparsecs from the galactic centre (**11**). The latter profiles probably include many neutral hydrogen clouds of the Gould Belt type in relative motion.

Other profiles in the present survey were broader and showed more complex structure. Those at $l'=330°$, $b'=+20°$ and $l'=330°$, $b'=+40°$ showed a broad base with a narrow bright peak. Some of these regions more than 20° away from the plane have values of η as large as 12 km/sec.

The centre frequency referred to the local standard of rest of the profiles plotted in Fig. 5 was determined to an accuracy of ± 5 Kc/s(± 1 km/sec) by referring spectra taken near the galactic plane to spectra in the catalogue of Muller and Westerhout. There is a significant departure of the centre frequency of most spectra from the zero of the l.s.r. The spectra representative of the Gould Belt region, i.e. near $l'=330°$, $b'=+20°$ and $l'=150°$, $b'=20°$ show a centre frequency at -15 Kc/s($+3$ km/sec) which represents small but significant recession of this neutral hydrogen.

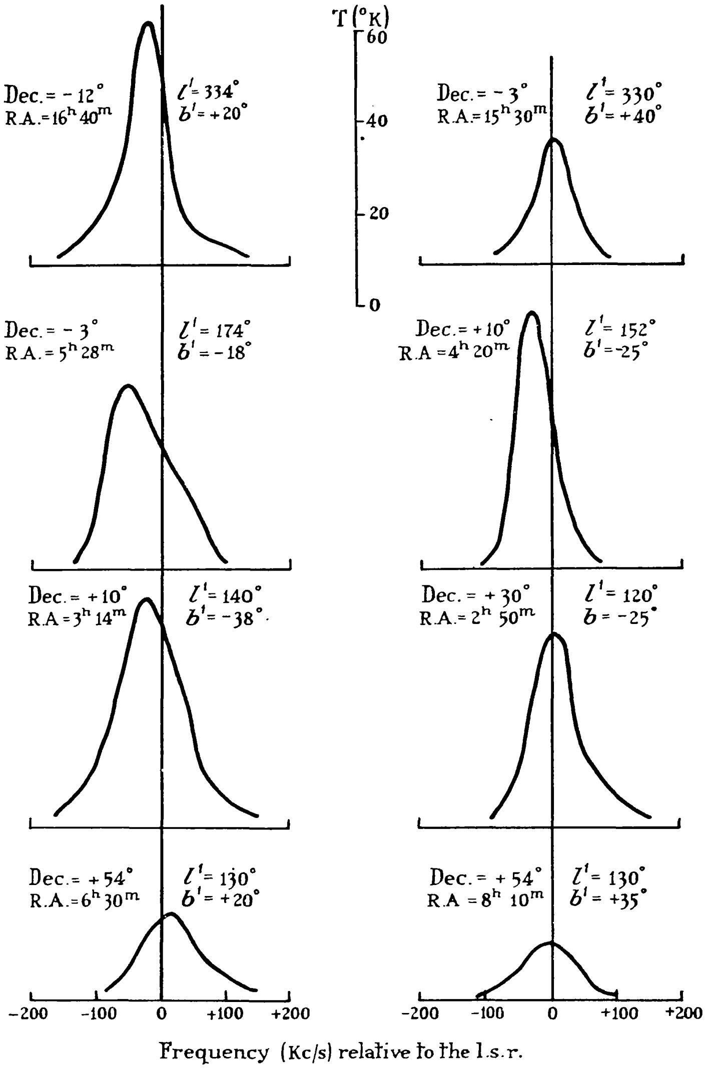

FIG. 5.—*Narrow band (25 Kc/s) profiles taken in regions away from the galactic plane.*

TABLE II

Properties of spectra taken in some regions of large N observed away from the galactic plane

Dec. °	R.A. (1958) h	m	l'	b'	Peak temp °K	N units of 10^{20}cm^{-2}	Width of T spectrum, Kc/s	η Km/sec	centre freq. relative to l.s.r., Kc/s
−26	17	43	330	0	93	95	170	10·1	−13
−12	16	40	334	+20	53	20	70	6·0	−13
− 3	15	30	330	+40	27	9	70	7·4	+ 3
+26	5	43	150	0	106	80	105	9·0	− 5
− 3	5	28	174	−18	37	19	127	11·5	−15
+10	4	20	152	−25	55	16	67	5·8	−20
+10	3	14	140	−38	48	28	125	11·1	−10
+30	2	50	120	−25	42	16	80	7·6	− 3
+54	6	30	130	20	18	9	100	10·5	+13
+54	8	10	130	35	10	5	115	12·1	+10

Erickson *et al.* have plotted the departure of the centre frequency from the l.s.r. of spectra for which $|b'| > 20°$. These show a velocity contraction of 5 km/sec for $|b'| > 40°$ and at their low latitude limit of $b' = \pm 20°$ they check the present results. Thus there appears to be an inward movement of neutral hydrogen near the Sun at high galactic latitudes as distinct from an outward movement within the plane of the Gould Belt system. The properties of each of the spectra taken in the present 25 Kc/s survey are summarized in Table II.

4. *Features of the spatial contours of N.*—The main features of the distribution of N, the integrated number of neutral hydrogen atoms per cm^2 in the line of sight, are to be found plotted in Fig. 4 (*a*), (*b*), (*c*) and (*d*) and may be described as follows:

(i) The greatest values of N lie along the "radio" galactic plane ($b'' = 0$) which is inclined at 1°·5 to the Lund plane ($b' = 0$). The maximum value of N on the plane is about 150×10^{20} atoms per cm^2 and the minimum is 70×10^{20} atoms per cm^2

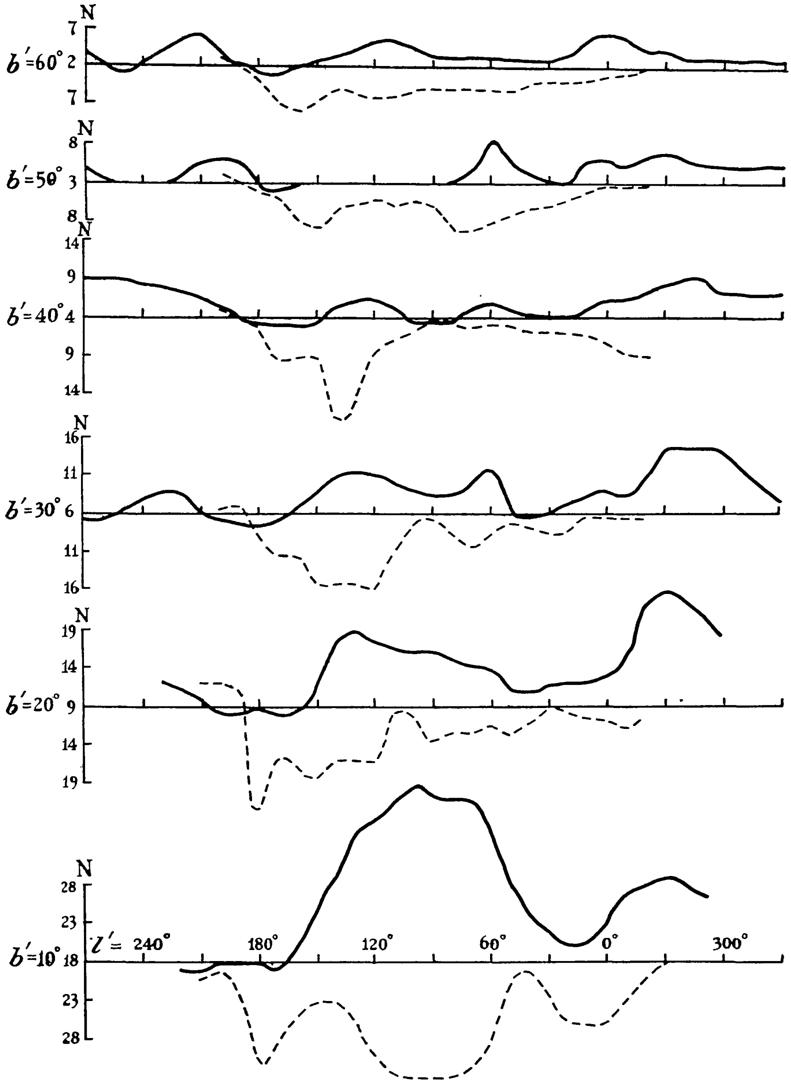

Fig. 6.—*The distribution of N in longitude between latitudes 10° and 60°. The plot for the northern hemisphere is a full line above, and that for the southern a broken line below a fiducial level for each latitude.*

assuming a kinetic temperature of 125°K. There are significant amounts of neutral hydrogen in both polar regions where values of N in the range 2 to 4×10^{20} atoms per cm^2 are found at $|b'| > 70°$.

(ii) The main departures from symmetry of N about the galactic plane and about the galactic centre are summarized in Fig. 6 which shows the distribution of N with galactic longitude plotted at 10° intervals of latitude. The values of N for the northern hemisphere are plotted above, and those for the southern hemisphere are plotted below a fiducial baseline. The major asymmetries are (*a*) a bulge about the galactic plane in the longitude range 60° to 120° extending from $b' = +15°$ to $b' = +5°$ and (*b*) the local sub-system of Gould's Belt seen above the plane from $l' = 220°$ to 350° and below the plane from $l' = 110°$ to 190°; it can be traced out to latitudes of 30° and 40° above and below the plane.

(iii) Concentrations of neutral hydrogen of limited extent were seen away from the galactic plane in a number of regions. Fourteen which were separated from the background distribution are listed in Table III. For each is assigned a position, extent and a value of ΔN, the increment of N above the surroundings. In addition the last three columns of the table show optical data which will be discussed below.

TABLE III

The properties of 14 regions of enhanced neutral hydrogen emission

H I region designation	l'	b'	Extent $l \times b$	N units of 10^{20} cm^{-2}	Obscuring clouds	Bright nebulae	Extragalactic absorption (mags)
			° °				
A	0	−20	35 × 10	5	Present ?		1–2
B	60	+35	10 × 7	6			1–2
C	65	+50	15 × 8	6			1–2
D	60 to 120	+ 5 to +15	60 × 10	15	Present	C	Avoidance
E	70	−28	10 × 5	6			0
F	70	−50	15 × 5	5			1–2
G	110 to 190	0 to −40	80 × 40	10	Present		Avoidance
H	120	−30	10 × 15	8	Present		1–2
I	140	−40	15 × 15	15	Present	C (Pleiades)	2
J	155	−55	10 × 10	5			0
K	175	−20	10 × 25	18	Present	C + E (Orion)	Avoidance
L	220 to 350	+ 5 to +30	130 × 25	10	Present	C (Scorpio etc)	Avoidance
M	320	+45	30 × 20	6	Present		1–2
N	340	−40	30 × 10	5			0 ?

5. *The distribution of N in latitude.*—A representative picture of the amount of neutral hydrogen at high galactic latitudes can be gained from a study of the latitude distribution of N. Accordingly the average value of N observed at each latitude was plotted against latitude for the northern and southern hemisphere in Fig. 7. To avoid any effect of the biasing of these plots by the sum of localized regions a second set of plots for each hemisphere was derived from the average of the ten lowest values of N (found in any 10° longitude interval) for each latitude. These are of similar shape to the former plots but are reduced by about 30 per cent in magnitude; they probably represent the broad distribution of neutral hydrogen at high galactic latitudes.

The plots were fitted to a uniform thickness model of the galactic neutral hydrogen using a secant-law analysis. The *minimal* distributions were fitted by layers above and below the Sun of $N = 2{\cdot}3 \times 10^{20}\,\mathrm{cm}^{-2}$ and $3{\cdot}1 \times 10^{20}\,\mathrm{cm}^{-2}$ respectively. The *average* distributions were equivalent to layers above and below the Sun of $N = 3{\cdot}5 \times 10^{20}\,\mathrm{cm}^{-2}$ and $4{\cdot}3 \times 10^{20}\,\mathrm{cm}^{-2}$ respectively. The difference between the *minimal* and *average* distributions may be ascribed to the effect of the non-uniform neutral hydrogen distribution near the Sun already discussed. Both distributions suggest that the Sun lies above the neutral hydrogen galactic plane with some 20 per cent more hydrogen below the plane than above it. If the distribution of neutral hydrogen in the solar neighbourhood is taken as uniform with a thickness of 220 parsecs (**12**) then the above 20 per cent difference would be accounted for if the Sun were about 22 parsecs above the neutral hydrogen plane. Analysis of stellar distributions indicates that the Sun is 13 parsecs above the stellar galactic plane (**13**).

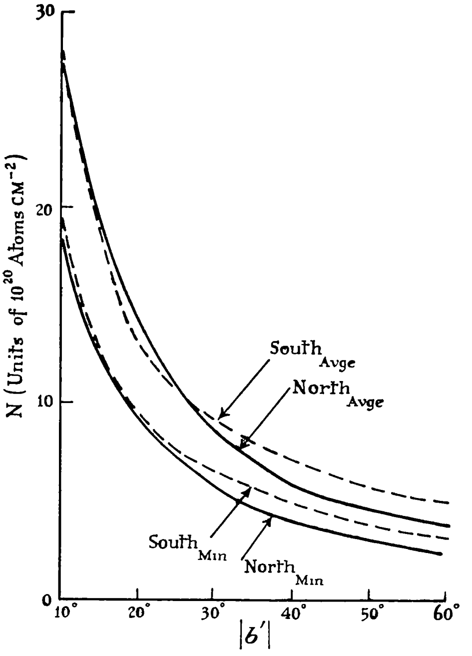

FIG. 7.—*The distribution of N in latitude averaged over all values of longitude. Minimal values are also plotted. The full line is for the northern hemisphere, the broken line for the southern.*

The observed amount of neutral hydrogen at high galactic latitudes can be compared with that expected from the observed value of N within the galactic plane and the known dimensions of the galaxy as mapped in neutral hydrogen. For example, the value of N within the galactic plane in the Cygnus direction is $150 \times 10^{20}\,\mathrm{cm}^{-2}$ which is integrated over a depth of about 8 kpc. The value expected at high latitudes with a depth of about 100 parsecs is accordingly about $2 \times 10^{20}\,\mathrm{cm}^{-2}$ if we assume the H I density in the solar neighbourhood to be that of the average in the line of sight in the direction of Cygnus. In view of this assumption, the agreement is good with the value of $2-3 \times 10^{20}\,\mathrm{cm}^{-2}$ observed for the minimal distributions.

6. *A comparison of the neutral hydrogen distribution with optical features.*—The correlation between the density of neutral hydrogen and the existence of dust clouds has already been established for a number of regions within the galaxy (**14**, **15**, **16**). The present study has included an examination of types of Population I objects which are known to co-exist with neutral hydrogen in the spiral arms of the galaxy.

(i) *Obscuring clouds*

A map prepared by Lundmark (**17**) shows the positions and sizes of those dust regions in which the star density is less than 5 or 6 times the surroundings. In consequence the higher latitude regions may be in error, being only statistical fluctuations in star density. All those dust clouds greater than 1·0 degree in diameter have been plotted in the maps of N in Fig. 4 (*a*), (*b*), (*c*) and (*d*).

A correlation is visible between many features of the distribution of obscuring matter and the distribution of neutral hydrogen away from the galactic plane. There is an excess of obscuring matter in the plane of the local system (regions G and L) in the well-known dust regions of Taurus, Orion and Auriga which lie below the galactic anticentre and the regions of Ophiuchus, Scorpio and Scutum above the galactic centre. The bulge seen in the neutral hydrogen distribution above the plane between longitudes 60° and 120° in Cepheus (region D) also has a counterpart in Lundmark's map; this region is a dust complex about 500 parsecs distant (**4**). There also appears to be good evidence for an excess of obscuring matter in the small regions A, H, I, K and M. These correlations are indicated in column 6 of Table III.

Hubble's (**18**) measurements of the effect of galactic obscuring matter on counts of extragalactic nebulae give another indication of the distribution of local obscuring matter. The agreement with the general features of Lundmark's catalogue is good and in all cases where there was a correlation between the 21 cm measures and Lundmark's obscuring clouds there was a clear deficiency in the counts of extragalactic nebulae. Hubble's observed number deficiencies have been converted into magnitudes of absorption in column 8 of Table III. The zone of avoidance of extragalactic nebulae coincides with the shape of the local system and also with the Cepheus bulge.

(ii) *Bright nebulae*

Cederblad's (**19**) catalogue of continuous reflection and of emission nebulae gives the distance as well as the size of clearly distinguishable galactic nebulosities. Those nebulae with distances less than 1000 parsecs have been divided among the quadrants centred on the axis of the local system ($l'=150°$, $l'=330°$) in Fig. 8 (*a*) and the perpendicular axis in Fig. 8 (*b*). Their positions above or below the plane and their diameters have been plotted. The local system is clearly seen separated from the galactic distribution. It lies inclined at 20° to the radio galactic plane ($b''=0$). These clouds of dust and gas extend for 200 parsecs in the direction of $l'=330°$ and 300 parsecs in the direction of $l'=150°$. The more extensive bright complexes are noted in column 7 of Table III where their spectral character is given (E for gaseous emission and C for continuum reflection from dust). These regions are interwoven with the obscuring matter plotted on Lundmark's map and are at the same distance. The variation of N with galactic latitude integrated over each quadrant is given as a polar plot by the full-line in Fig. 8 (*a*) and (*b*). The correlation between N and the existence of interstellar dust is again marked.

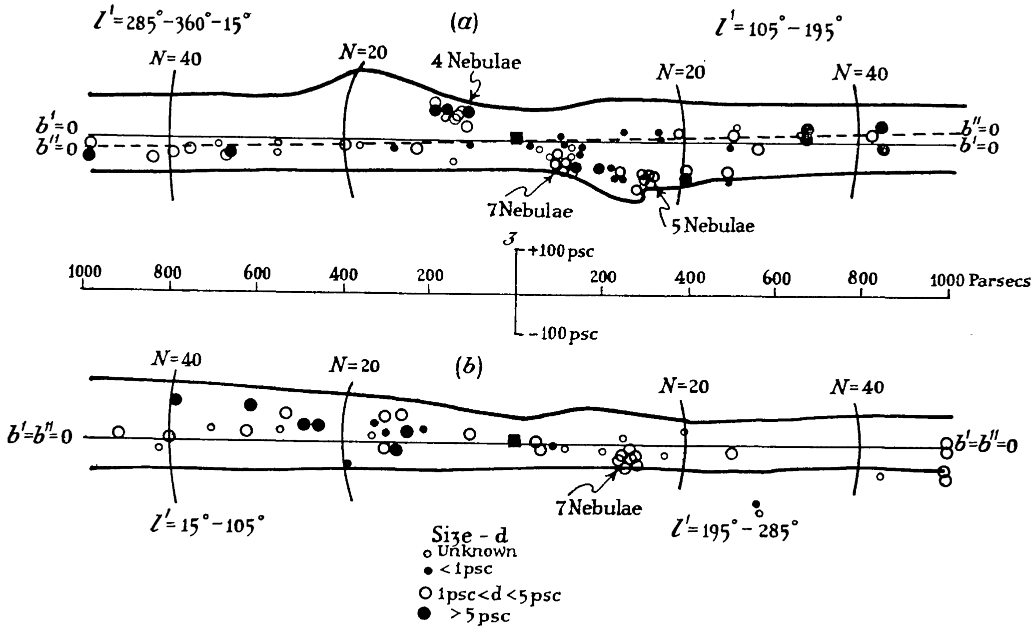

FIG. 8.—*The distribution in height (z) above the galactic plane of bright nebulae (after Cederblad) averaged for each quadrant of longitude. The corresponding distribution of N is given by the full line polar plot.*

(iii) *The distribution of stars*

The spatial distribution of stars in the solar neighbourhood has already been discussed in the introduction. The nearby early-type stars lie within the local system inclined at about 20° to the galactic plane. A large number of these are of spectral type B_5 to B_9 which indicates (**20**) an age of 20×10^6 years for the local system. This may be compared with $100\text{–}200\times10^6$ years for the bulk of the stars in the solar spiral arm.

7. *A comparison with radio continuum surveys.*—Recent publications have indicated that there may be some correlation between the distribution of neutral hydrogen and the brightness distribution of the continuum radiation from the Galaxy. Mills (**21**) has found 81 Mc/s radiation from spiral structure within the Galaxy and Blythe (**22**) has shown that some 38 Mc/s continuum details seen in the Taurus region are also visible in the neutral hydrogen contours. More evidence relating to this correlation was derived from a study of the present neutral hydrogen survey and from continuum surveys which have been made with beamwidths of less than about 10° i.e. comparable with the resolution of the present survey. The results are plotted in Fig. 9 (*a*) and (*b*) for frequencies of 38 (**22**), 200 (**23**), and 400 (**24**) Mc/s. The values are the average brightness temperatures within $\pm 5°$ of the latitudes indicated.

An examination of these plots shows that there is no close correlation between the continuum emission at any frequency and the neutral hydrogen distribution at galactic latitudes near $\pm 20°$. The only feature which produces an effect in both line and continuum radiation is the Orion complex of gas and dust. This is not unexpected since the continuum radiation comes from an extended region showing the Hα emission centred on the Orion Nebula. Moreover the continuum spur at $l' = 0°$ reaching to high positive latitudes has no counterpart in the neutral hydrogen distribution with the resolution of the present survey.

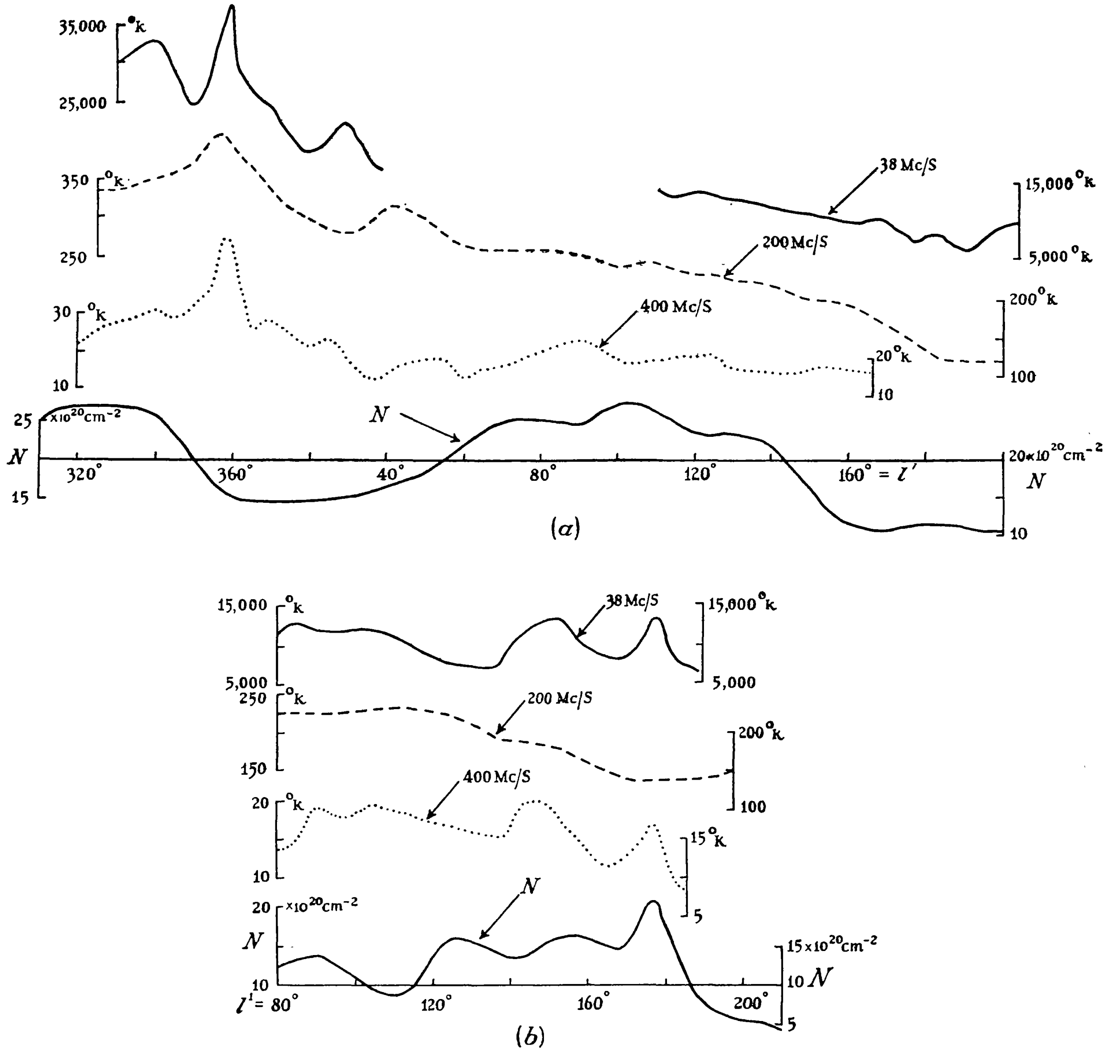

FIG. 9.—*The distribution in galactic longitude of N and continuum radiation for (a) $b' = +15°$ and (b) $b' = -20°$.*

8. *The mass of gas, dust and stars in the local system.*—The mass of neutral hydrogen in the local system (Gould's Belt) can only be estimated if the dimensions of the system can be derived. Since the neutral hydrogen distribution is so closely correlated in position with the dust complexes of the local system, it will be assumed here that the hydrogen is distributed in depth the same way as the dust. Thus the hydrogen will be taken to have a uniform density towards $l' = 330°$ out to 200 parsecs (the Ophiuchus and Scorpio clouds) and towards $l' = 150°$ out to 300 parsecs (the Taurus, Orion clouds). The equivalent depth of the hydrogen perpendicular to the galactic plane is 30 parsecs as derived from the width to half-intensity in latitude of $\sim 15°$. The corresponding breadth in the direction $l' = 60°$ to $l' = 240°$ is estimated at 150 parsecs (width $\sim 70°$) although it is difficult to determine because the local system here crosses the galactic plane and might just as well have been taken as 500 parsecs i.e. making the region a circular disk. The neutral hydrogen in the former case is 10^5 solar masses ($M_\odot$) and in the latter $2{\cdot}6 \times 10^5 M_\odot$. The hydrogen gas density in this idealized representation of the local system is 2·0 atoms per cm^3 in excess of the gas density within the local spiral arm.

The mass of the dust in the system was calculated using the same dimensions and taking the obscuration along the major axis to be 2 magnitudes as read from Hubble's counts of extragalactic nebulae. The line of sight dust mass, m', was derived using the expression (16) $m' = 3 \times 10^{-5}\, m$ gr cm^2 where m is the absorption in magnitudes. The dust masses of the two models used in the neutral hydrogen calculations were $2{\cdot}5 \times 10^3\ M\odot$ and $6 \times 10^3\ M\odot$ respectively. The neutral hydrogen gas mass is 40 times that of the dust.

The mass of stars in the local system is not readily calculable. Schmidt (**5**) gives an approximate estimate of $10^8\ M\odot$ for a system 500 parsecs in radius. The major uncertainty lies in determining the number of low luminosity stars in the system. An approach to the problem can be made using the fact that the A type stars with apparent magnitudes less than 6 lie in a plane inclined to the galactic plane at 4° compared with 16° for the B stars within 200 parsecs (**2**). This indicates that A stars within the local system amount to only about 30 per cent of the A star density in the field stars of the local spiral arm. Assuming the mass of the local system consists mainly of A and later type stars with a space density 30 per cent of that in the local spiral arm, a useful estimate can be made from the known density of field stars (**25**). The stellar mass of the local system calculated in this way lies in the range of 10^4 to 10^5 solar masses, and would appear to be less than the mass of hydrogen in the system. This result may be compared with the fraction of neutral hydrogen in the spiral arm near the Sun which amounts to 10 per cent (**26**).

9. *Conclusion*.—The present study of the distribution of neutral hydrogen away from the galactic plane shows a close similarity to the distribution of young stars in the local system proposed by Shapley. Neither distribution is smooth although the major features of one appear on the other. The reality of this system is further strengthened because it consistently exhibits the characteristics of a young Population I object—young stars and a high percentage of gas and dust. It then would appear to be a "recent" phenomenon in the local spiral arm if this data can be interpreted in an evolutionary sense. The "bulge" seen in the dust and neutral hydrogen distributions in the direction of Cepheus may be a similar type of system. This can only be substantiated if data on the type and distance of the stars embedded within it become available.

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Jodrell Bank Experimental Station,
Lower Withington,
Cheshire:
1959 *September.*

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