NEUTRAL HYDROGEN WITH HIGH VELOCITIES AT HIGH GALACTIC LATITUDES

A. N. M. HULSBOSCH AND E. RAIMOND

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During the years 1963–1965 a systematic search was made for high-velocity hydrogen objects at latitudes $|b| \geq 20^\circ$. The observations are still in progress. In 30 out of 500 line profiles high-velocity objects have been definitely detected. The angular extent of two of them has been determined. The areas observed around some others are as yet too small to comprise the entire objects. A preliminary discussion of the nature of these objects and their origin is given by Oostr (1966).

In this paper all radial velocities are given with respect to the local standard of rest (l.s.r.).

1. Introduction

This paper describes the high-velocity part ($|V| \geq 70$ km/sec) of 21-cm line observations at high galactic latitudes ($|b| \geq 20^\circ$) made in the Netherlands before the autumn of 1965. Since the coverage of the northern sky is much more complete at high negative velocities than it is at positive velocities, we do not intend to present a full discussion of the material available. This paper must rather be considered as a progress report of our observations. A more definite discussion will follow when more observations are available.

2. Observations

The observations were obtained with the 25-metre telescope of the Dwingeloo Radio Observatory during two periods. Until the end of 1963 a quasi-degenerate parametric amplifier was used in combination with the 8-channel receiver described before (Van Woerden et al., 1962; Raimond, 1966). From 1964 onwards the same parametric amplifier was used with a new 20-channel receiver. The parametric amplifier and the 21-cm line receiver have been designed and built by Professor C. A. Muller and the staff of the Dwingeloo Observatory.

The 1963 observations are published separately (Muller et al., 1966) together with a description of the parametric amplifier and of the zero-line corrections applied after the standard reduction (Raimond, 1963, 1966). Details of the 20-channel observations (1964 and later) will be given later. Examples of 8-channel profiles are given in figure 3, of 20-channel profiles in figure 4.

The positions of the line profiles discussed in this paper are given in figure 1. The ranges of radial velocity covered by the line profiles and the i.f. bandwidths used are given in table 1. A survey at positive velocities over the entire northern sky is in progress. Also a five-degree grid of observations at negative velocities is being made in the area $50^\circ \leq l^{\prime} \leq 180^\circ$, $+20^\circ \leq b^{\prime} \leq +90^\circ$ (cf. section 5.3).

In addition to the surveys mentioned above line profiles have been obtained in denser grids around some high-velocity objects. The results of these observations will be described in section 5.

3. Radiation at high velocities

The survey positions on which 21-cm radiation with high radial velocities ($|V| \geq 70$ km/sec) has been detected have been indicated in figure 2. The parameters of these radiation peaks are given in table 2. The peaks

<table>
<thead>
<tr>
<th>Table 1 High-latitude surveys</th>
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<tr>
<td>$b$</td>
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<tr>
<td>---</td>
</tr>
<tr>
<td>$\delta^{I}$</td>
</tr>
<tr>
<td>$\delta^{I}$</td>
</tr>
<tr>
<td>$\delta^{II}$</td>
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</tbody>
</table>
Figure 1. Positions observed. Open circles indicate positions observed both at negative and positive velocities (1963), dots denote positions observed only at negative velocities (1965). The radial velocity ranges and bandwidths used are summarized in table 1. The limit below which no observation can be made from Dwingeloo ($\delta = -38^\circ$) has been indicated in the figure. In practice the survey has been extended down to $\delta = -30^\circ$. 
Figure 2. High-velocity peaks have been found at the positions indicated. The numbers are radial velocities with respect to L.S.R. in km/sec. More details of these peaks are given in Table 2.
associated with features for which some indication of the angular extent is available (cf. section 5) have been named in the column “object”. Special observations for this purpose have been made near the positions indicated with an asterisk.

The reality of the peaks, of which some examples are shown in figure 3, is well confirmed. All of them have been detected in at least two, and usually four or more independent observations. Quite a number of peaks which are still subject to considerable doubt have not been included in table 2.

Although stray radiation may contribute to the line profiles, it is very unlikely that it will produce distinct peaks at very high velocities. In general it will result in low-intensity wings to the profiles and mainly at low velocities. The sensitivity of the spillover ring reported before (Van Woerden et al., 1962; Raimond, 1966) has been reduced considerably by the construction of a new feed. No correction for stray radiation has been applied to the observations.

A property which all peaks have in common is a large half-width: the smallest $W$ is 14 km/sec, while the majority of the quantities $W$ is over 20 km/sec. This cannot be due to instrumental effects, since the largest bandwidth used is 10 km/sec.

4. Distribution in velocity; distribution over the sky

The most striking feature in table 2 is that all velocities are negative. In mentioning this feature we must keep in mind that the survey at negative velocities is
complete in the northern sky as a 10-degree grid, while this is not the case at positive velocities.

Nevertheless one third of the peaks in table 2 were found in a survey of 200 positions observed both at negative and positive velocities, while half of the remaining peaks (feature OA) may be connected with a feature at lower latitudes (see below). Therefore it seems justified to conclude that high negative velocities predominate over high positive velocities at high latitudes in the part of the sky visible from the Netherlands. The only object at high latitude with a moderately high positive velocity is that reported by Kerr (1965, 1966) at $l^I = 262^\circ.5$, $b^I = +23^\circ.4$, $V = +75$ km/sec. The velocities of the peaks of feature OA at $b^I = +20^\circ$ fit the curve $V = -133$ sin $(l^I - 14^\circ)$ reasonably well. They seem to be connected with the feature at lower latitudes which Habing (1966) interprets as an extension of the outer spiral arm of the Galaxy. We shall not discuss this feature any further.

The distribution of the remaining peaks shows a strong preference for the area $70^\circ \leq l^I \leq 170^\circ$, $+30^\circ \leq b^I \leq +50^\circ$, although some high-velocity objects have been found at negative latitudes. One of the latter is near the galactic south pole (see also Dieter, 1965),
5. Angular extent and physical parameters of some objects

5.1. Object A

The angular extent of this object has been determined from observations in a one-degree grid over an area of roughly 7 x 7 square degrees. A map of surface densities is given in figure 5. The observational and physical parameters of object A are summarized in table 3. The latter are dependent on the distance r, for which no estimate can be given at present. Object A is the only high-velocity object bright enough to show some details in the velocity distribution of the hydrogen gas. Three of the central profiles (figure 6) seem to consist of two components each about 15 km/sec wide and separated by approximately 10 km/sec. In the fourth profile of figure 6, one of the components is missing. The other profiles are too weak to draw a conclusion about their shape.

5.2. Object B

This object is considerably smaller and weaker than object A. It was detected in 13 out of 25 profiles in a half-degree grid around \( l^\odot = 167^\circ.5, b^\odot = +38^\circ.5 \). The profiles of a larger one-degree grid did not show the object. The parameters of object B are given in table 3.

5.3. Cloud complex

After the discovery of two very similar high-velocity peaks in two profiles only five degrees apart (Muller et al., 1963), we observed a two-degree grid of profiles
Figure 7. Surface densities in the observed part of the area occupied by a cloud complex. The diameter of the circles corresponds to the beamwidth of the Dwingeloo telescope. The numbers are the radial velocities of the observed peaks in km/sec.
Table 3

Parameters of two high-velocity objects

<table>
<thead>
<tr>
<th></th>
<th>Object A</th>
<th>Object B</th>
</tr>
</thead>
<tbody>
<tr>
<td>co-ordinates of max. $T_b$:</td>
<td>$l^\Pi$</td>
<td>$b^\Pi$</td>
</tr>
<tr>
<td></td>
<td>153°.3</td>
<td>168°.0</td>
</tr>
<tr>
<td></td>
<td>+ 38°.5</td>
<td>+ 38°.6</td>
</tr>
<tr>
<td>$V$ (km/sec)</td>
<td>-175</td>
<td>-158</td>
</tr>
<tr>
<td>max. $T_b$ (units)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>max. $N_H$ (10^19 cm$^{-3}$)</td>
<td>3.7</td>
<td>1.1</td>
</tr>
<tr>
<td>equivalent apparent diameter $d$</td>
<td>3°.5</td>
<td>1°.3</td>
</tr>
<tr>
<td>total mass $M$ (M$_\odot$·kpc$^2$)</td>
<td>2500 r$^2$</td>
<td>150 r$^2$</td>
</tr>
<tr>
<td>density $n_H$ (cm$^{-3}$·kpc$^{-3}$)</td>
<td>0.8 r$^{-1}$</td>
<td>0.8 r$^{-1}$</td>
</tr>
</tbody>
</table>

The equivalent apparent diameter is the diameter of a hypothetical spherical cloud with a uniform space density $n_H$, having the same total mass and maximum surface density as the observed object.

in the area $80^\circ \leq l^\Pi \leq 94^\circ$, $+34^\circ \leq b^\Pi \leq +46^\circ$ in 1963, and a three-degree grid in the area $88^\circ \leq l^\Pi \leq 100^\circ$, $+40^\circ \leq b^\Pi \leq +61^\circ$ in 1965. As may be seen in figure 7 it turns out that the high-velocity gas probably extends over a still larger region than has now been observed. Measurements in a five-degree grid covering the area $50^\circ \leq l^\Pi \leq 180^\circ$, $+20^\circ \leq b^\Pi \leq +90^\circ$ are now in progress.

The velocity and the surface density of the gas in this region vary rather irregularly between $-108$ km/sec and $-150$ km/sec (cf. figure 6). Whether the complex consists of many isolated objects similar to objects A and B (cf. sections 5.1 and 5.2) or whether it is more or less amorphous with local condensations, cannot be concluded before we have observations in a grid with spacings of 1° or preferably even 0.5°. Unfortunately this requires much observing time.

5.4. Object C

The velocity of this object ($-70$ km/sec) is considerably smaller than those of the other objects discussed. An attempt was made to determine its angular extent by taking profiles in a two-degree grid in the area $102^\circ \leq l^\Pi \leq 120^\circ$, $+34^\circ \leq b^\Pi \leq +46^\circ$. It turned out that object C extends below $b^\Pi = +34^\circ$ and below $l^\Pi = 102^\circ$. At $l^\Pi = 102^\circ$ the peak of object C begins to be blended with the much brighter low-velocity peak of the profiles. It is remarkable that the velocity of the object is nearly constant ($-70$ km/sec) for $b^\Pi \geq +36^\circ$ but is 10 km/sec higher ($-80$ km/sec) at $b^\Pi = +34^\circ$ at all longitudes observed.

6. Concluding remarks

From the descriptions given in section 5 it must be clear that it is practically impossible to derive typical characteristics of a high-velocity object. Most objects observed are so weak that it will take many more observations to obtain details about their sizes and internal velocity distributions. More data on the distribution of high-velocity objects over positive and negative velocities will be available later this year. A systematic search for high-velocity objects of the southern hemisphere is very important, in order to obtain a more complete picture of the distribution over the sky.

Acknowledgements

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References


F. J. KERR, 1966, private communication


