OH_{1667} LINE ABSORPTION AT $2° < l^{II} < 4°$, $-0°30' < b^{II} < 1°$

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Abstract

The OH absorption line at 1667 MHz has been traced from $l^{II} = 2°$ to $4°15'$ near the galactic plane. Line profiles and contours of apparent opacity are presented. The measurements have completed the general picture of absorbing hydroxyl gas in the vicinity of the galactic centre and suggest the existence of a gradient of radial velocities of values near -136 km sec^{-1} at $l^{II} = 359°$ to values near $+141$ km sec^{-1} at $l^{II} = 3°30'$.

I. Introduction

In an earlier survey of the absorption of the OH line at 1667·358 MHz near the galactic centre (McGee 1970*a*, 1970*b*; Robinson and McGee 1970) the observations were restricted to longitudes less than $l^{II} = 3°$. However, it became apparent that when the effects of the continuum background were removed (McGee 1970*a*) the OH gas complex must extend to well beyond $l^{II} = 3°$.

The Mark II line receiver described by Batchelor, Brooks, and Sinclair (1969) had sufficient sensitivity to enable OH line absorption to be traced from $l^{II} = 2°$ to about $4°15'$ near the galactic plane. Thus we have been able to complete the overall picture of the absorbing hydroxyl gas at 1667 MHz in the galactic centre–Sagittarius region as far as the limits of our resolution in angle and frequency permit.

II. Equipment and Observations

Observations were made with the 210 ft radio telescope at Parkes and were combined with the initial tests of the Mark II receiver and its interface with the Mark I 48-channel filter network. The receiver was switched at 39 Hz between the signal antenna feeding the paraboloid and a broad-beam reference sky horn. Balance of the two inputs was achieved by feeding noise from a neon discharge tube into both arms through voltage variable attenuators and directional couplers. The system noise temperature was approximately 200°K. The first stage of the receiver was a single-tuned nondegenerate parametric amplifier at centre frequency 1666 MHz.

The local oscillator arrangements included a phase-locked reflex klystron held constant by reference to the fourth harmonic of a signal from a frequency synthesizer. The input frequency was converted in two stages to an intermediate frequency of 6·7 MHz. At this point the interface enabled it to be transferred to a bank of 48 filters of half-width 37 kHz tuned at intervals of 33·2 kHz across the reception

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band. The detected outputs were returned to the Mark II receiver for synchronous detection, integration, storage on paper tape, and display on an X–Y recorder.

Intensity calibration was maintained with an argon noise source applied at regular intervals and checked by comparison with radiation from the radio source Hydra A. For these observations and others with the Mark II receiver, the ratio of flux density to aerial temperature has been taken as 1·59 f.u.* per degree Kelvin and the flux density of Hydra A as 36 f.u.

Frequency calibration was effected by checking the synthesizer and other oscillators against a caesium beam frequency standard.

The aerial beam was measured as 12′·5 arc. Profiles were observed at intervals of 15′ arc between galactic longitudes 2° and 4°15′ and galactic latitudes −0°30′ and +0°45′ and at several extra positions at $b^{\rm II} = -0°22'·5$ and +1°. An integration time of ~4·5 min per profile was used; the r.m.s. value of the noise fluctuations was ±0·09 degK. Examples of the noise can be seen in some of the observations where no line is detected, e.g. at $b^{\rm II} = -0°30'$, $l^{\rm II} = 4°15'$ in Figure 1(*a*) and at $b^{\rm II} = +0°30'$, $l^{\rm II} = 2°$ in Figure 1(*e*).

III. Results: OH-line Absorption Profiles

Figures 1(*a*)–1(*e*) show the 48-channel profiles recorded at the five galactic latitudes −0°30′, −0°15′, 0°, +0°15′, and +0°30′ in the range of galactic longitude 2° to 4°15′ where OH absorption was detected. Profiles for the additional points outside this network are given in Figure 2. Partially smoothed curves have been sketched through the points representing the intensities of the channels. The ordinates are aerial temperature in degrees Kelvin and the abscissae radial velocities in km sec^{-1} referred to the local standard of rest.

Comparison with the atlas of profiles in the galactic centre region (McGee 1970*b*) illustrates the large improvement in signal-to-noise ratios. Absorption features between 0·5 and 1°K are recognized with ease. The absorption features are similar in general character to the more intense ones observed in the neighbouring area. It is again possible to trace the main OH features through the series of profiles alone, although there is a great tendency for individual features to blend into single broad profiles. An example is the extremely wide profile at $b^{\rm II} = +0°30'$, $l^{\rm II} = 3°15'$ in Figure 1(*e*), whose half-width is 147 km sec^{-1}.

Rapid changes are noticeable in some regions. In changes of just over one aerial beamwidth spectacular differences of profile can be noted; for example, at $b^{\rm II} = +0°15'$ and +0°30′ and $l^{\rm II} = 2°45'$ to 3°30′ in Figures 1(*d*) and 1(*e*).

IV. Apparent Opacity

The temperature of the continuum background $T_{\rm c}$ was measured at the same time as each profile. If all the contributions to the continuum intensity were behind

* 1 flux unit (f.u.) = 10^{-26} W m^{-2} Hz^{-1}.

Figs 1(*a*)–1(*e*).—Profiles of the 1667·358 MHz line of OH at the indicated values of galactic latitude and ranges of galactic longitude. The coordinates are aerial temperature (absorption) in degrees Kelvin and radial velocity in km sec^{-1} referred to the local standard of rest.

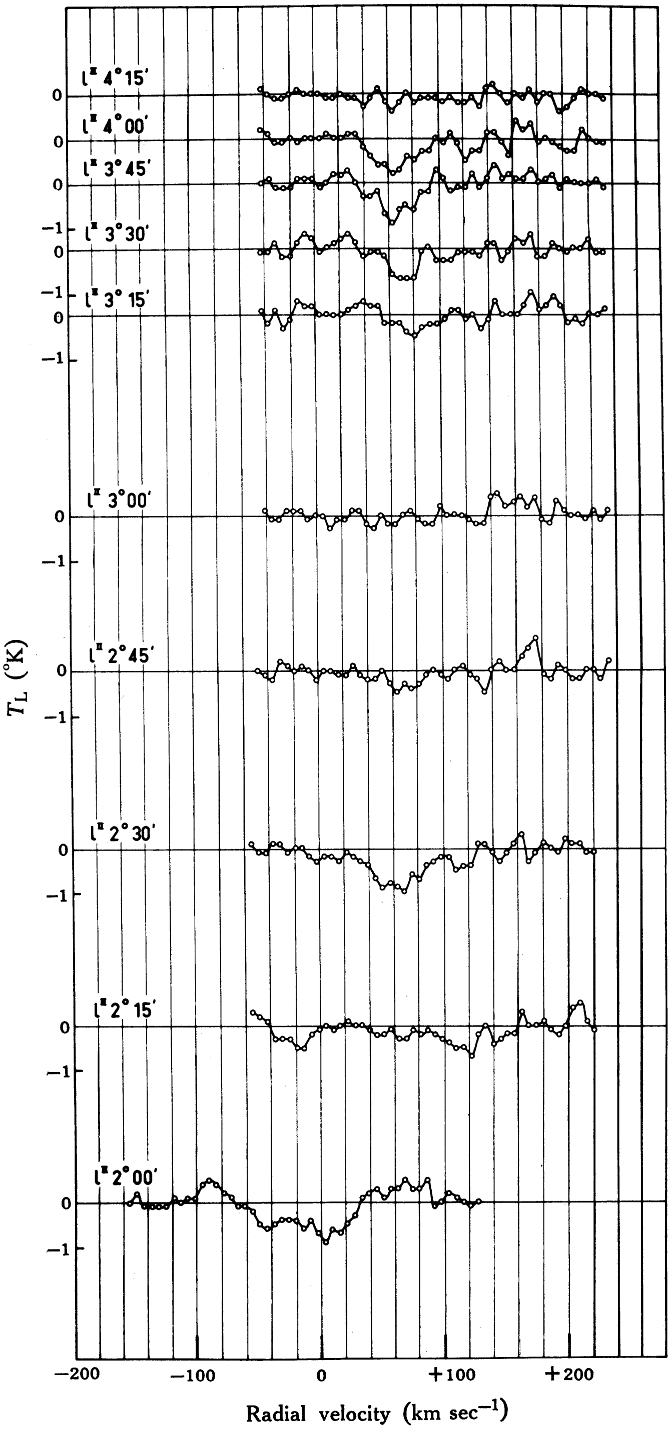

Fig. 1(*a*). $b^{II} = -0°30'$, $2° \leqslant l^{II} \leqslant 4°15'$

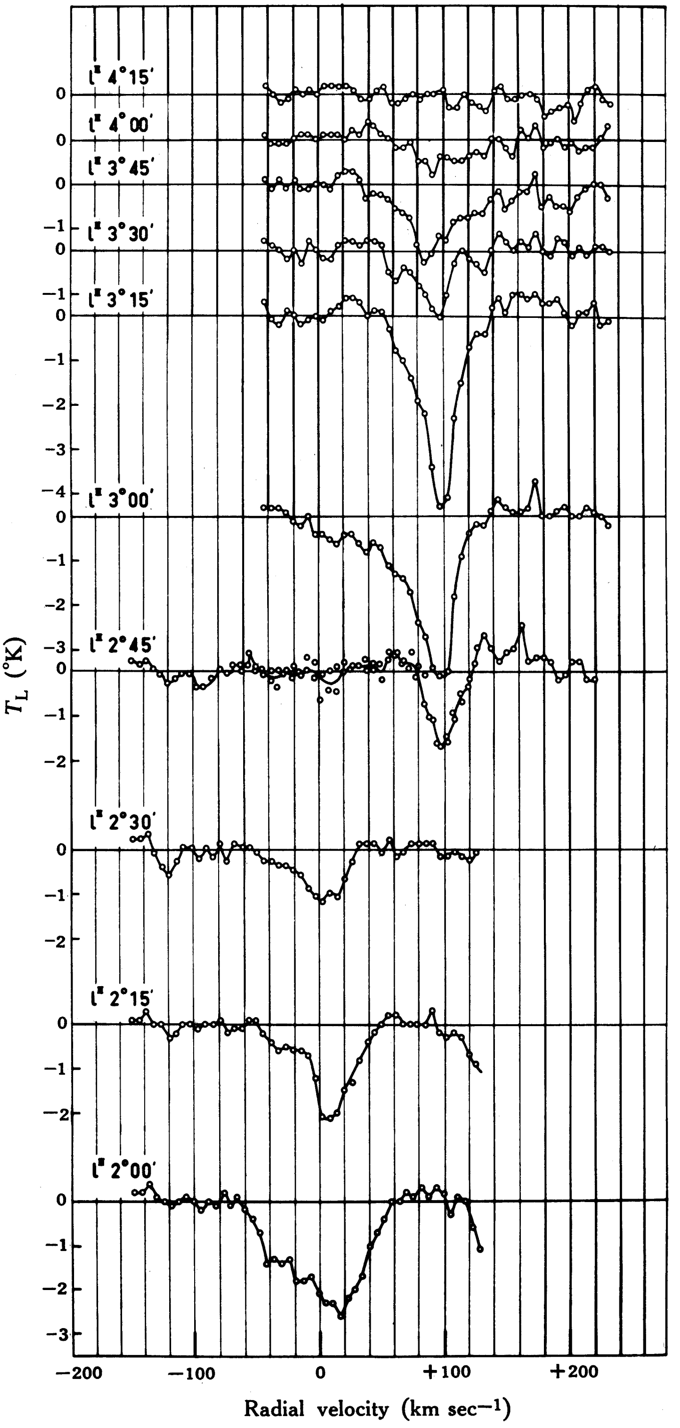

Fig. 1(*b*). $b^{II} = -0°15'$, $2° \leqslant l^{II} \leqslant 4°15'$

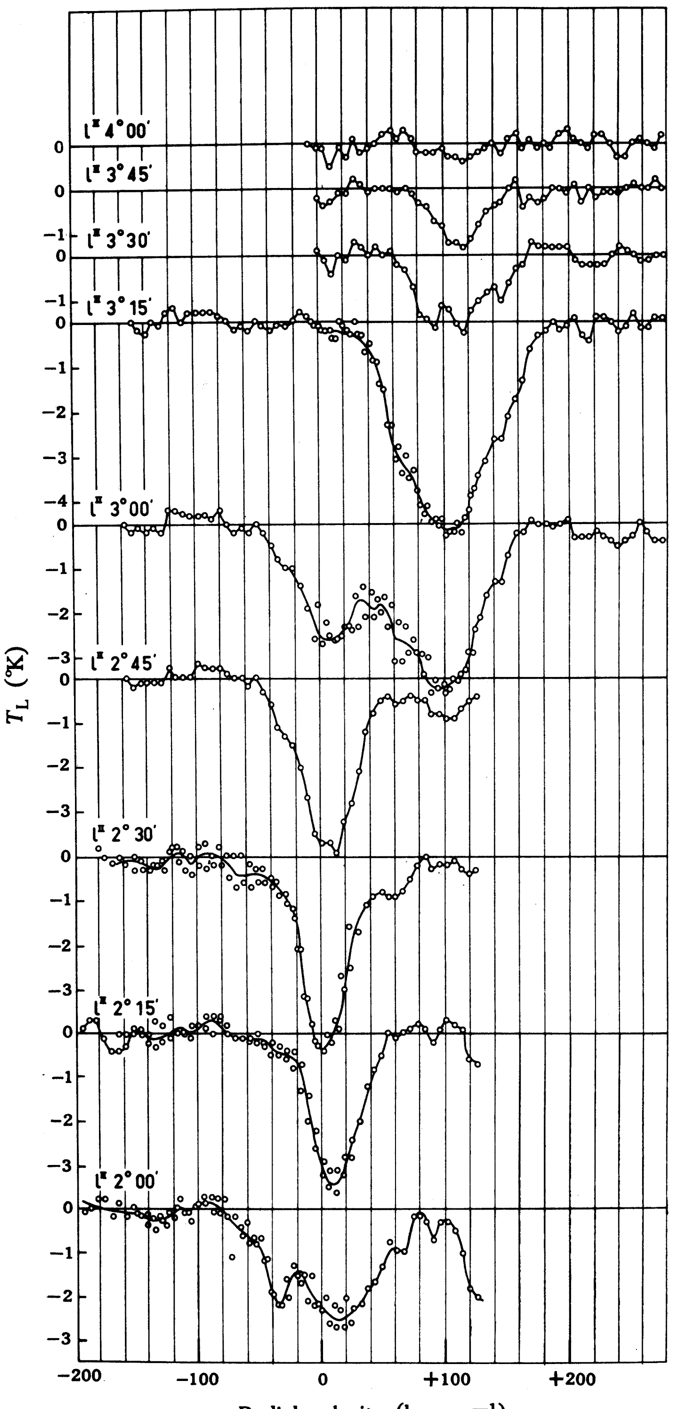

Fig. 1(*c*). $b^{II} = 0°$, $2° \leqslant l^{II} \leqslant 4°$

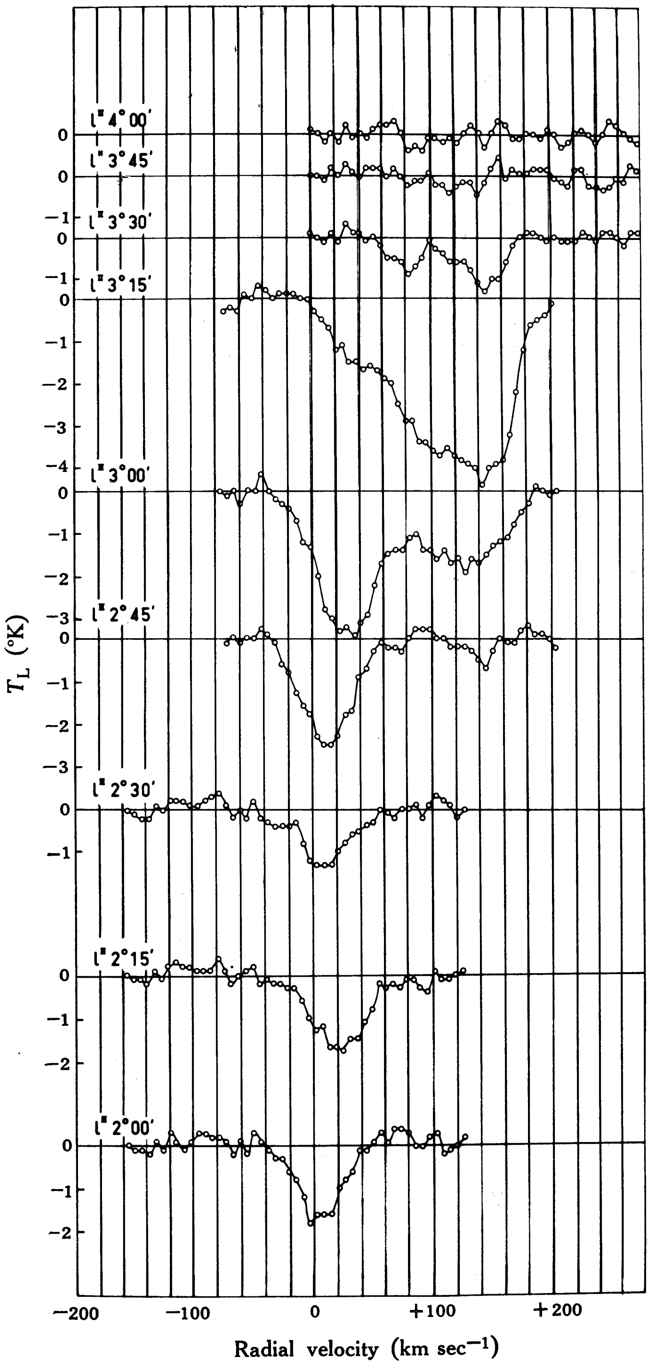

Fig. 1(*d*). $b^{\mathrm{II}} = +0°15'$, $2° \leqslant l^{\mathrm{II}} \leqslant 4°$

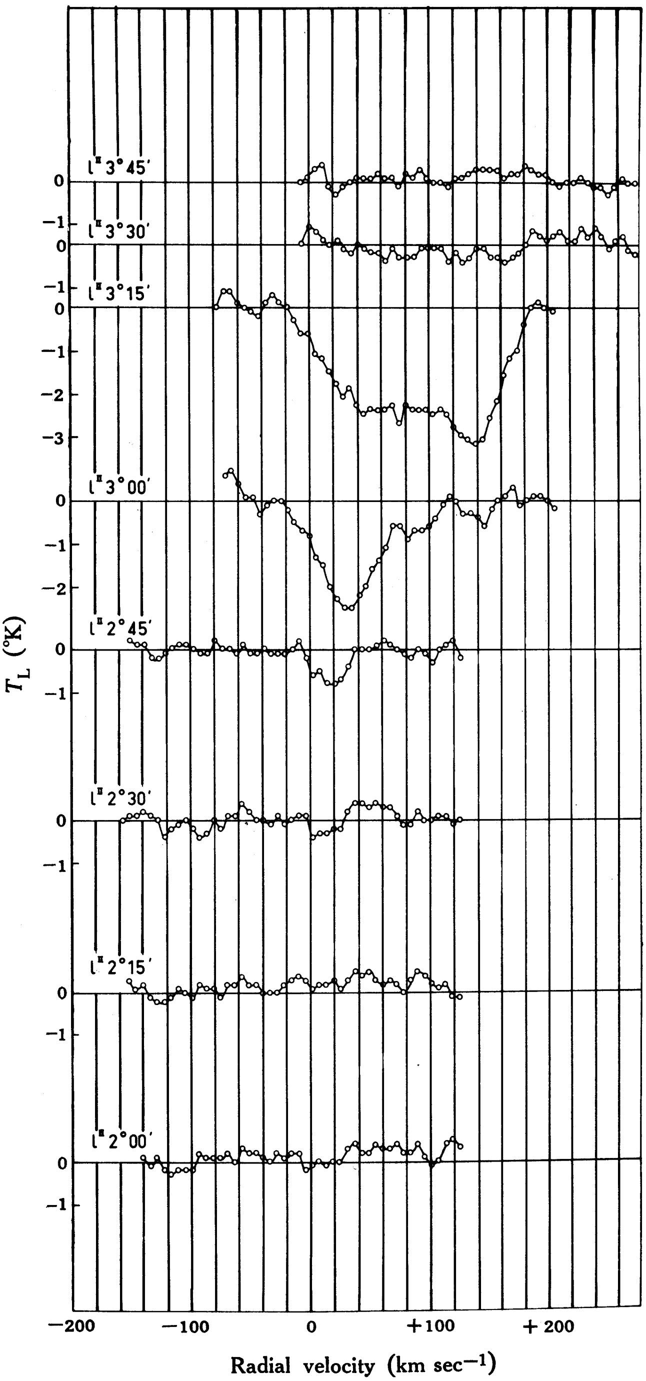

Fig. 1(*e*). $b^{II} = +0°30'$, $2° \leqslant l^{II} \leqslant 3°45'$

the absorbing gas the optical depth τ for OH could be calculated from the relation

$$T_L = T_c(1-e^{-\tau}),$$

where T_L is the line absorption temperature. Such an assumption cannot be made, but a quantity called apparent opacity, $\tau_a = T_L/T_c$, serves to normalize the effect of the changing continuum background and gives, to first order, the apparent form in which the OH gas may exist. Contours of apparent opacity are given in Figure 3.

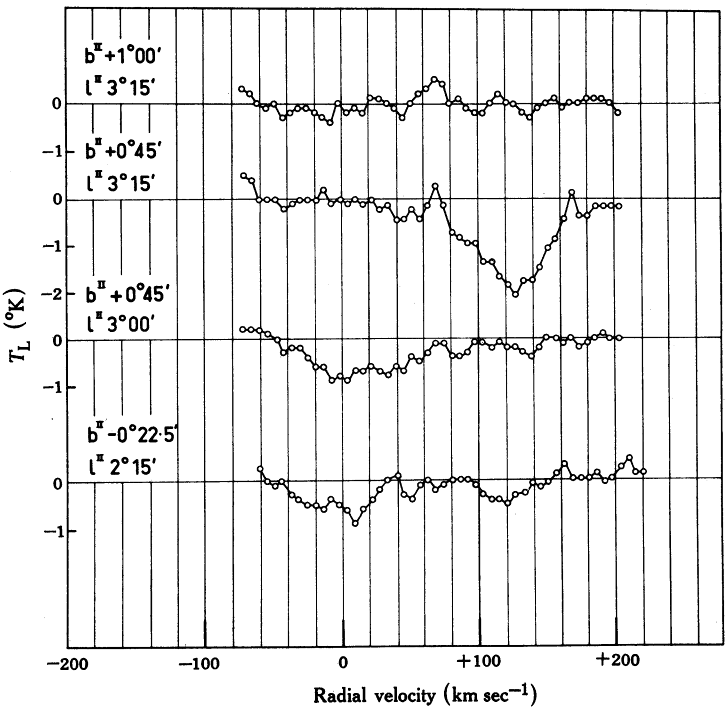

Fig. 2.—Additional profiles of the 1667·358 MHz line of OH at the indicated latitudes and longitudes.

The contours, in units of 0·05 in τ_a, are plotted on coordinates of galactic longitude and radial velocity for the six galactic latitudes $b^{II} = -0°30'$, $-0°15'$, $0°$, $+0°15'$, $+0°30'$, and $+0°45'$. Shading has been used to accentuate the intense features.

In general the apparent opacity contours support the previous incomplete findings by McGee (1970*a*). The low values of absorption temperatures and the fact that intense τ_a features appeared near the edge of the diagrams in that paper required caution in accepting their reality. However, all the features in the $l^{II} = 2°$ to 3° range are closely confirmed here, with the exception that the intensities at $b^{II} = -0°30'$, $l^{II} = 2°20'$ between velocities 0 and $+50$ km sec^{-1} are lower than in McGee (1970*a*) and there is only slight evidence in the present profiles of a feature at velocity 100 km sec^{-1} at $b^{II} = -0°15'$, $l^{II} = 2°30'$ suggested by McGee (1970*a*).

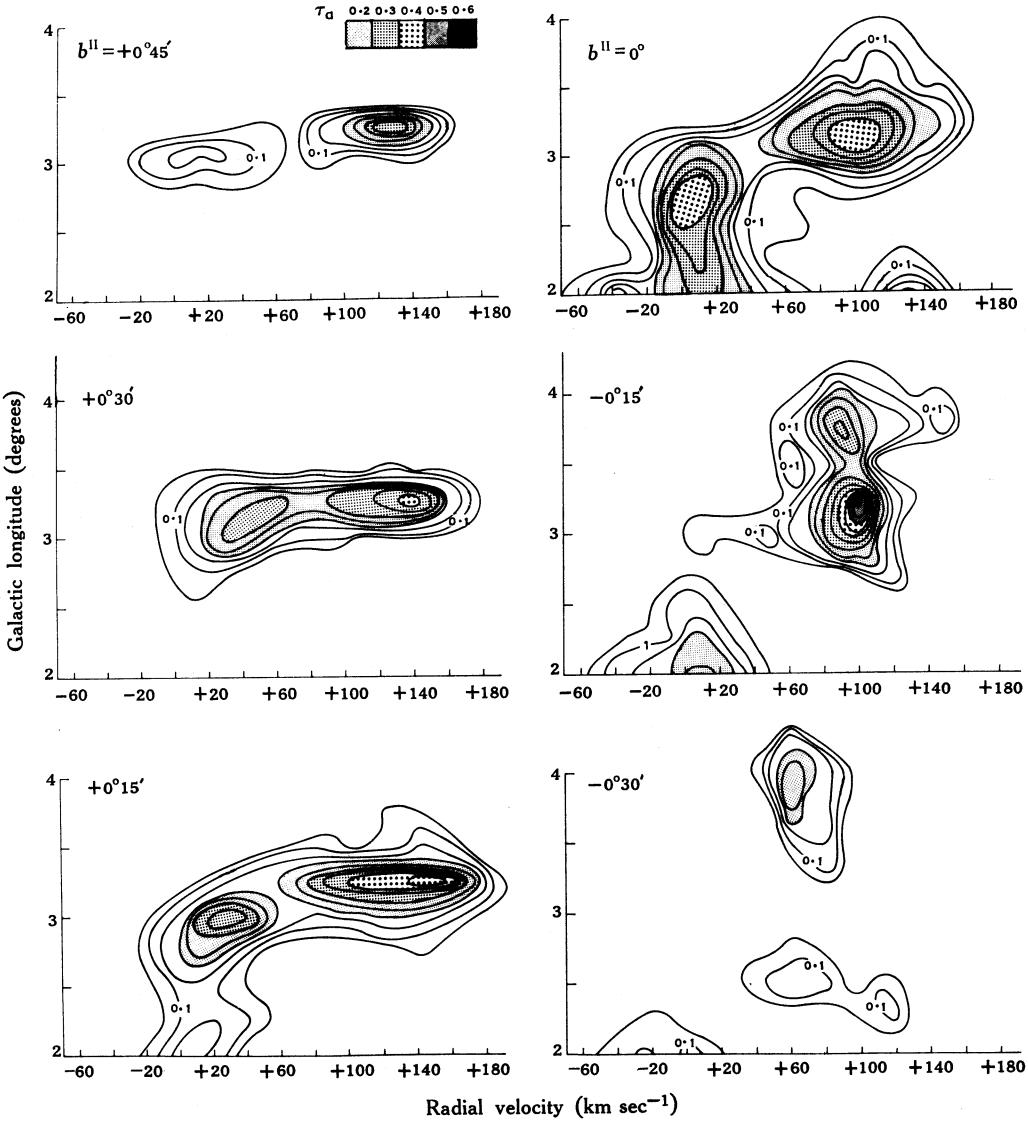

Fig. 3.—Six contour diagrams of apparent opacity τ_a on coordinates of galactic longitude and radial velocity at the indicated values of galactic latitude. The contour interval is 0·05.

The change in appearance of the contours from diagram to diagram in Figure 3 indicates that the 15′ arc spacing of the observations is not sufficient to delineate individual clouds. However, the half-widths in galactic longitude Δl were measured at intervals of 20 km sec^{-1} between radial velocities −20 and +140 km sec^{-1} in Figure 3. The mean of 46 values was 29′·3 arc. The half-widths in galactic latitude Δb were measured for the same velocities by plotting profiles of τ_a against b^{II}. The mean of 27 values was 26′·0 arc. These may be compared with the means found for OH clouds by McGee (1970*a*) of $\Delta l = 26'\cdot 0$ arc and $\Delta b = 17'\cdot 6$ arc.

V. Radial Velocity Pattern

Estimates have been made for the positions and radial velocities of the features of τ_a in Figure 3. Four features dominate with mean values as follows: $+7$ km sec^{-1} at $l^{II} = 2°50'$, $b^{II} = 0°$; $+48$ km sec^{-1} at $l^{II} = 3°05'$, $b^{II} = +0°30'$; $+106$ km sec^{-1} at $l^{II} = 3°08'$, $b^{II} = -0°15'$; and $+141$ km sec^{-1} at $l^{II} = 3°23'$, $b^{II} = +0°15'$. If these results are combined with the OH cloud velocities across the galactic centre (McGee 1970*a*) a pattern of radial velocity gradient with longitude emerges.

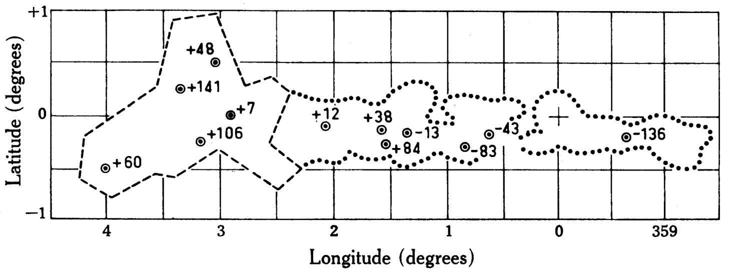

Fig. 4.—Sketch of the envelope of hydroxyl gas clouds in the general vicinity of the galactic centre for $l^{II} = 358°30'$ to $4°15'$, $b^{II} = -1°$ to $+1°$. Average radial velocities (km sec^{-1}) are marked at representative positions.

Figure 4 is a schematic illustration of the distribution of the hydroxyl gas in the general vicinity of the galactic centre. It has been sketched from the envelope of the OH cloud representation given by McGee (1970*a*) and the information from Figure 3 to cover a range of $l^{II} = 358°30'$ to $4°15'$.

The mean positions and radial velocities of the seven groups of OH clouds discussed by McGee are marked within the dotted outline. These groups were assembled on the criteria of similar values of radial velocity. In some cases the spread of a velocity range is considerable; for example, the value $+38$ km sec^{-1} marked at $l^{II} = 1°36'$ is the mean of 18 values spread over 3° of longitude.

The velocities marked within the dashed outline are those of the four main features mentioned above and a secondary feature of radial velocity $+60$ km sec^{-1} at $l^{II} = 4°$, $b^{II} = -0°30'$. The features are blends of hydroxyl clouds.

We conclude from Figure 4 that a gradient of radial velocity with longitude exists. High negative values occur near $l^{II} = 359°$, high positive values near $l^{II} = 3°30'$.

VI. Conclusions

We have used the improved sensitivity of the Mark II line receiver to extend the investigation of hydroxyl gas in the Sagittarius–galactic centre vicinity from $l^{II} \sim 2°$ to $\sim 4°15'$. Although the maximum absorption temperatures measured were only $\sim -4°$K, the continuum background temperature also falls off in this region; the apparent opacity contours present the same characteristics in intensity and distribution as those previously observed.

The measured radial velocities enabled the completion of a pattern in which an apparent gradient of velocities exists across the OH gas distribution from negative values near -136 km sec^{-1} at $l^{II} = 359°$ to values near $+141$ km sec^{-1} at $l^{II} = 3°30'$.

VII. References

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