THE 4830 MHz FORMALDEHYDE LINE OBSERVATIONS OF DARK CLOUDS IN IC 1795 (W3)

Y. K. MINN*
Max-Planck-Institut für Radioastronomie Bonn, Germany
and
J. MAYO GREENBERG
State University of New York at Albany,
and
Dudley Observatory U.S.A.

Abstract. A survey of H_2CO absorption in dark clouds in IC 1795 (W3) shows that the material in the direction of W3 can be distinctly separated into three groups: one, immediately surrounding W3, has a uniform velocity of about -41 km^{-1} s; the second, associated with the W3 (OH) source has a velocity of about -49 km^{-1} s; the third, as a velocity of about -20 km^{-1} s and may be associated with an interarm spur in the foreground.

1. Introduction

As a part of the survey of dark clouds in the galactic plane in the l_{11}–l_{10}, 4830 MHz transition of H_2CO (Minn and Greenberg, 1973), we observed dark clouds in the region of IC 1795 (W3). IC 1795 is the youngest object of the group of three H II regions in the Perseus arm, the others being IC 1805 (W4) and IC 1848 (W5). It has OH and H_2CO emission sources 17′ southeast of the main radio continuum source (Cudaback *et al.*, 1966; Rogers *et al.*, 1966; Knowles *et al.*, 1969) and large extinction in front of, as well as in, areas surrounding the main radio source. Lynds (1962) lists 13 dark clouds subtending from 0.016 to 0.2 sq deg in the vicinity of IC 1795. The area has been mapped in detail by Mezger and Henderson (1967), Mezger *et al.* (1967), and Wynn-Williams (1971) at various wavelengths using both the single dish and the interferometer. Mezger *et al.* (1967) found that a compact H II region is associated with the OH emission source (W3 (OH), G133.9+1.0) which is completely hidden from view in the Hα photograph. Wynn-Williams (1971) derived the magnitude of the extinction in front of W3. It is enormous, -14 mag. in Hα, and it hides some of the exciting stars completely. An infrared star is also reported in the region within 30″ from the OH emission source (Raimond and Eliasson, 1969).

It is the purpose of this work to obtain the radial velocities of dark clouds in the area and to determine their distribution and relation with H II regions and the OH emission source.

Observed positions are indicated in Figure 1 in which is also shown a contour map of the continuum antenna temperature at 5 GHz taken from Mezger *et al.* (1967).

* Present address: Dept. of Physics and Astronomy, University of Alabama.

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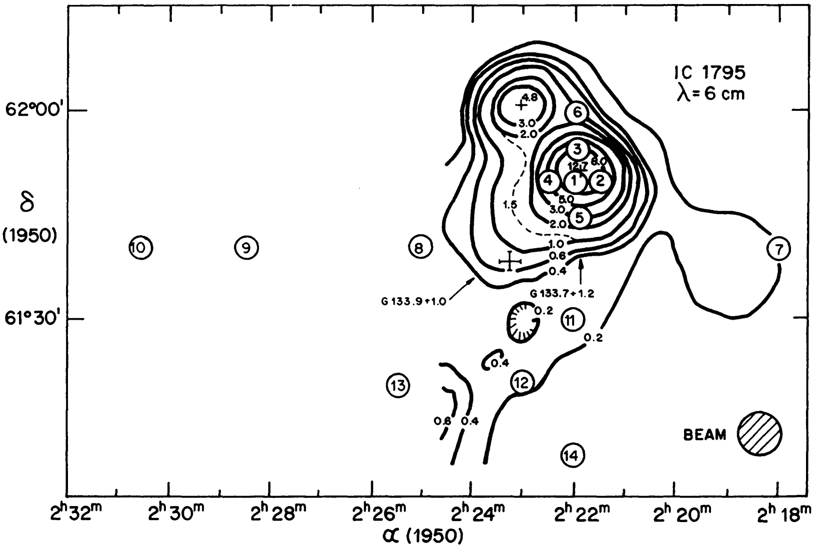

Fig. 1. Positions at which 6-cm formaldehyde observations were made, shown against 6-cm continuum contour map of IC 1795 taken from Mezger *et al.* (1967). 1 unit = 1 K T_A.

Due to limited observing time we restricted our observations to the darkest areas in the representative regions. In the W3 continuum center area observations were made close to each other in order to determine the velocity variation and the fall-off of the H_2CO line against the radio source background. For most other positions, the continuum background contribution from the radio source is so low, generally less than 0.3 K, that the absorption is mostly that against the universal microwave background 2.8 K.

The observations were carried out with the 140-ft telescope at the National Radio Astronomy Observatory* equipped with a cooled 6-cm parametric amplifier and the 413-channel autocorrelation receiver. The total system noise temperature was typically about 100 K and a spectral resolution of either 6.5 kHz (0.4 km s^{-1}) or 3.2 kHz (0.2 km s^{-1}) was used. The data were taken in the 'total power mode'.

2. Results and Discussion

Observational results are presented in Table I and Figure 2. In Figure 2 representative line profiles are shown: one against the W3 radio source and two against the universal microwave background – one with strong lines and the other with weak lines. Column 1 of Table I gives the cloud number; Columns 2 and 3 are equatorial coordinates of the observed positions; Column 4 is the radial velocity of the line with respect to the local standard of rest (Allen, 1964); Column 5 is the measured antenna temperature of the line; Column 6 is the full line width at half-intensity; Column 7 is

* Operated by Associated Universities, Inc., under contract with the National Science Foundation.

TABLE I

Summary of the observations

Position number	α(1950)	δ(1950)	V_{1sr} (km s^{-1})	T_1 (K)	W (km s^{-1})	T_c (K)
1.	$2^h\ 22^m\ 00^s$	61° 50′ 00″	−41.2	−1.17	3.5	12.7
			−22.2	−0.30	1.0	
2.	2 21 30	61 50 00	−40.5	−0.80	3.5	8.0
3.	2 22 00	61 55 00	−41.2	−1.10	3.3	8.0
4.	2 22 30	61 50 00	−41.2	−0.70	3.3	5.0
5.	2 22 00	61 45 00	−40.5	−0.20	0.3	3.0
6.	2 22 00	62 00 00	−51.3?	−0.25	0.3	1.0
7.	2 18 30	61 41 00	−52.4?	−0.14	0.4	<0.3
8.	2 25 00	61 41 00	−48.9	−0.25	0.3	<0.3
9.	2 28 30	61 41 00	−48.9	−0.27	0.3	<0.3
10.	2 30 30	61 40 00	−49.0	−0.26	0.3	<0.3
11.	2 22 00	61 30 00	−48.3	−0.29	0.3	<0.3
12.	2 23 00	61 20 00	−49.3	−0.34	3.4	<0.3
			−22.0	−0.21	2.3	
13.	2 25 30	61 20 00				<0.3
14.	2 22 00	61 10 00				<0.3

the 6-cm continuum antenna temperature, either taken from Mezger *et al.* (1967) or measured immediately before the line observation.

Lines were detected at most positions even though they are weak, indicating a wide distribution of the molecule in the region. At a few positions in less dark regions, the line strenghts and widths were reduced to a very weak level. In such cases, the line was confirmed by a careful tracing of the continuation of the line in adjacent positions as shown by the lower two traces in Figure 2. The narrow and weak features are typical characteristics of the H_2CO absorption against the universal microwave radiation in dark clouds as surveyed by the same authors (1973). Some of the lines observed here, however, are narrower than the lines typically found in dark nebulae. The average H_2CO line width in dark clouds is about 1.1 km s^{-1}. The lines observed here bear a resemblance to the weak high velocity lines ($V > 20$ km s^{-1}) observed in the dark cloud H_2CO survey. The kinematic distance of IC 1795 derived from the radio observation of the H 109α line is given as 3.1 kpc by Reifenstein *et al.* (1969). If the dark clouds are really associated with this bright nebula, they may be the most distant clouds identified so far.

At positions near the W3 radio continuum center, where the continuum background contribution from the radio source is high, line profiles are very deep and wide. They are very similar to those observed by Zuckerman *et al.* (1970) and Wilson (1972) against the radio continuum sources. The fall-off of the line against the *continuum source* background, away from the peak seems to be very rapid. At position 5 where the continuum antenna temperature is reduced to one-fourth of the peak antenna temperature of the source, the line almost disappears.

At position 1, which is in front of W3, and position 12, which is 30′ south of W3, absorption lines other than the main absorption (around −40 and −49 km s^{-1}) were

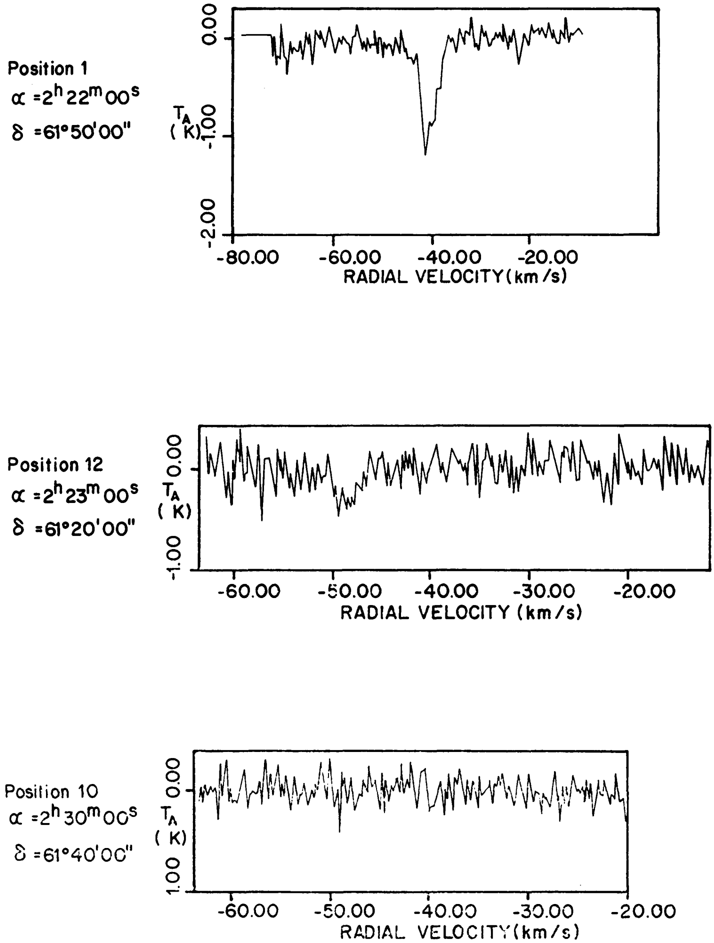

Fig. 2. Representative line profiles. Position 1 is against the W3 radio continuum background and positions 12 and 10 are against the universal microwave background.

detected at around -22 km s^{-1}. This feature was also detected at -21.6 km s^{-1} by Wilson (1972) in the direction of the W3 peak radio continuum. The large difference of velocities (about 20 km s^{-1}) of these lines from the main absorption suggests that these might be foreground clouds.

The velocity distribution of the H_2CO absorption lines is displayed in the plane of the sky in Figure 3. It is found that line velocities within the area of the W3 continuum center differ quite significantly from those in the surrounding regions. The velocity difference between the two areas is about 10 km s^{-1}. The velocity variation within each area seems to be negligible indicating there is little rotational or shearing motion. This result is consistent with the H109α-line survey in the region done by Rubin and Mezger (1970). Other molecular absorption lines in the direction of the OH emission source W3(OH) (which is between positions 8 and 11) show a similar velocity difference

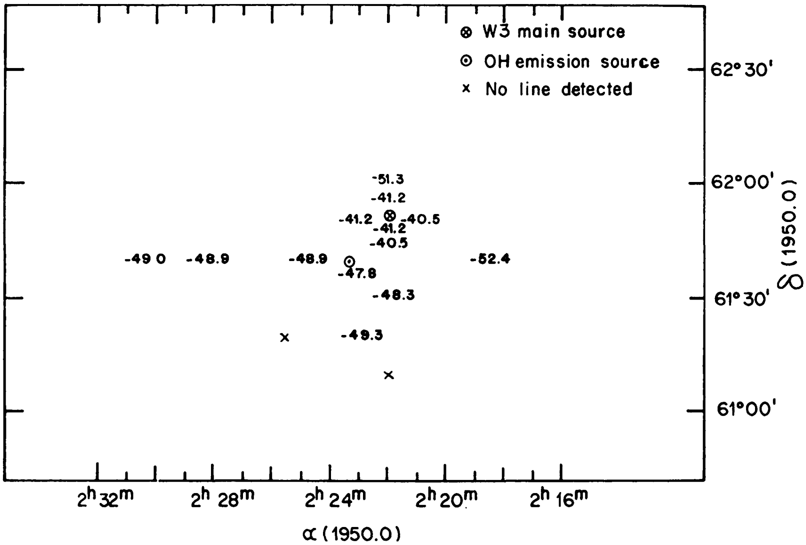

Fig. 3. The velocity distribution of the main absorption lines. Positions of the W3 center and OH emission source W3(OH) are also given.

from those of W3. All the known molecular and H 109α line velocities in both W3 and W3(OH) are given in Table II. Different line velocities for a source agree well with each other with the exception of the weak OH emission in W3. Velocities of the molecular and hydrogen lines in W3 listed in Table II, are also comparable with those of the H_2CO lines we observed in the W3 radio source area, while the H_2CO line velocities in the surrounding dust areas agree well with the molecular line velocities in W3(OH). The close agreement between the velocities of molecular lines which are supposed to be coming from the interstellar cold dust clouds (same authors, 1973) and

TABLE II

Radial velocities of radio lines

Line	W3 G133.7+1.2	W3 (OH) G133.9+1.0	Reference
H_2CO	−41.1(1)	−47.8(1)	(1) Zuckerman *et al.* (1970)
(absorption)	−40.1(2)	−45.9(2)	
OH	−54.2(4)	−46.5(3)	(2) Wilson (1972)
(emission)		−49.1(3)	(3) Barrett and Rogers (1966)
OH	−40.3(4)		(4) Turner (1970)
(absorption)	−40.0(5)		
			(5) Weaver, Dieter and Williams (1968)
H_2O (emission)	−40.7(6)	−46.6(6)	(6) Knowles *et al.* (1969)
H 109α	−41.8(7)		(7) Reifenstein *et al.* (1969)
H_2CO (140 GHz emission)	–	−48.0(8)	(8) Thaddeus *et al.* (1971)
HCN (88 GHz emission)	–	−49.0(9)	(9) Snyder and Buhl (1971)

– observed but not detected

the H109α line suggest that dark clouds in W3 are physically associated with the H II region as was suggested by Wynn-Williams (1971). The close agreement of the OH emission velocity of W3(OH) with the formaldehyde line velocities in the neighboring dark clouds indicates that the OH emission source is embedded in the dust clouds. These dust clouds are widely distributed in the region as indicated by the detection of the H_2CO line at most positions observed and as evidenced by large extinction indicated in the Hα plate of the *Palomar Sky Atlas*. If the OH emission source and the compact H II regions are recently formed stars out of dust clouds still surrounded by a 'cocoon' of dust and gas as suggested by Mezger *et al.* (1967), it is quite natural that we find these stars in dark cloud complexes. There is a possibility that the vast dark areas in the vicinity of IC 1795 are associated with the shell of IC 1805 which extends to this region.

The velocity deviation of the recently detected weak OH emission in W3 implies that this source is more likely to be well behind W3 than to be physically connected with it. The velocity of the OH emission (-54 km s^{-1}) corresponds to that of the H I peak intensity in the Perseus arm in this direction.

The velocity difference of about 10 km s^{-1} between W3 and its surroundings seems large enough to suggest that W3 (including the thick dark clouds in front of it) is physically separated from the surrounding features.

The additional absorption features with velocities of about -20 km s^{-1} are observed at only the W3 continuum center and at position 12 which is considerably separated

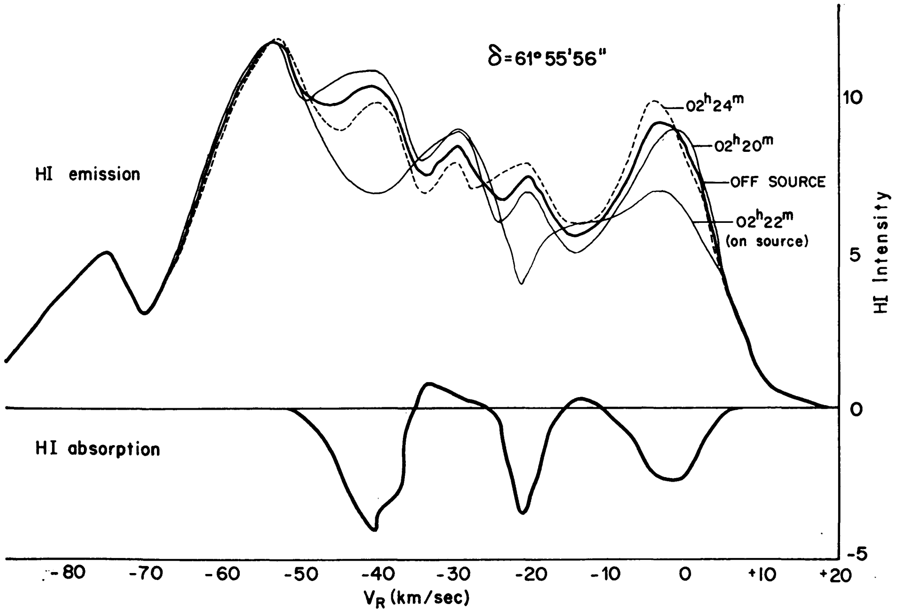

Fig. 4. H I emission and absorption line profiles constructed from the Maryland-Green Bank 21-cm Line Survey (Westerhout, 1969). The H I intensity unit in the ordinate corresponds to an antenna temperature of about 5 K.

from W3 and has no continuum contribution from it. Why this line is observed at only two contrasting and far separated positions is not known, but from their similarities in velocity it seems that they are located at foreground positions at about the same distance from us. A velocity of -20 km s^{-1} corresponds to an interarm spur of the H I distribution between the Orion and Perseus arms.

Strong H I absorptions were found in this direction in the Maryland-Green Bank 21-cm Line Survey (Westerhout, 1969). Absorption line profiles are constructed and presented in Figure 4. The H I survey is taken in the form of drift scans at constant declination. One such drift scan passes through $\delta = 61° 55'56''$ which is 4′ north of the radio center position of W3 and well within the continuum peak. For the expected line profile, we took the average of the H I intensities at 4 min east and west of the source. Three large cold H I clouds are found at velocities of about -2, -21 and -40 km s^{-1} respectively. Recent interferometric observations confirm this result (Wilson *et al.*, 1972).

The H I absorption at -2 km s^{-1} is not observed in the H_2CO line, but the other two agree well enough with the H_2CO absorption features to show that H_2CO dust and cold H I occupy the same space. If this is the case, part of the extinction observed in the direction of W3 and its vicinity is the result of the foreground dust associated with the H I spur.

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