CO DISTRIBUTIONS TOWARDS THE SOUTHERN DARK CLOUD OF DC 303.6+0.9

Jing-sheng Wang[1] and Robina E. Otrupcek[2]
1. Yunnan Observatory, P.O. Box 110, Kunming, 650011, P.R. China
2. Australian NRAO, P.O. Box 276, Parkes, N.S.W. 2870, Australia

ABSTRACT Dark clouds in the southern skies have been observed with CO J = 1–0 line. The mm-wave telescope of 4-m diameter was used. The beam width was $2'.7$ at 2.6 mm wavelength and beam efficiency 0.52. The authors have developed a high-resolution acousto-optical spectrograph with a velocity resolution of 0.07 kms^{-1} for this purpose. The 115.27 GHz line was detected over an area of $27' \times 21'$ including the dark cloud of DC 303.6+0.9 in Crux. Most of the positions, out of a total number of 63, show a double peak line structure. Some positions also show red and blue shifted wings. An average profile shows a higher peak at the radial velocity of -2.8 kms^{-1} with a calibrated radiation temperature of 5.5 K, a half line width of 1.5 kms^{-1}, and another peak in relative red at a velocity of -0.8 kms^{-1} with a temperature of 4.3 K, a half line widh of 1.0 kms^{-1}. Profiles distributed over this area show a bipolar diagram. It hints that a certain systematic motions may exist in this region.

1. INTRODUCTION

In the northern hemisphere the dark cloud CO line observations have already been done by many authors (e.g. Myers et al. 1983, Fukui et al. 1988, Snell et al. 1980 etc). In the southern hemisphere similar observations are still rare (Huggins et al. 1977, de Vries et al. 1984). Meanwhile the CO observation of the southern dark clouds have become more important because: (a) a number of prominent star-forming regions are situated in the southern skies, (b) an unbiases statistics for star-forming regions in our Galaxy appears significant in 1980s, and (c) some newly estabilshed powerful equipment in the southern hemisphere such as the Australian Telescope needs some preliminary survey to find the regions worth detailed investigation.

The authors commenced CO observations on the southern dark clouds in 1984 by means of a high-resolution acousto-optical spectrograph (AOS) associated with the 4-m mm-wave telescope of CSIRO Division of Radiophysics. Some preliminary results have already been published (Wang et al. 1987, Wang and Otrupcek 1987, 1988). Here we report another specimen which appears as a prominent double-peak line profile and a bipolar structure close to the direction of DC 303.6+0.9 (S 157) in Crux.

2. OBSERVATIONS

Observations were made in November and December 1986 with the 4-m mm-wave telescope at the rest frequency of 115.27 GHz which produced a half power beam width of $2'.7$ arc. The receiver provided a double side-band system temperature of 250 K. The beam efficiency was 52

A high-resolution AOS was used for these observatinos. The AOS was built by Chinese-Australian collaboration. The frequency resolution is 28 kHz. This yields a velocity resolution of 0.07 kms^{-1} at 115 GHz. It contains 1024 output channels. Each channel covers 10.5 kHz, i.e. 0.027 kms^{-1} at 115 GHz. The total bandwidth of the AOS covers a velocity range of 28 kms^{-1}. Details are described in Wang et al. (1989).

The calibration during observations was done by means of a beam-switch described in Robinson et al. (1982). The calibrated radiation temperature as defined by Kutner and Ulich (1981)

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was adopted. The atmosphere attenuation was precessed by regularly observing the sources of OMC-1 in Orion and the HII region of G333.1-0.43.

An area in Crux of 27′ arc (in EW) by 21′ arc (in NS) was observed at 3′ arc of grid intervals. Nine additional adjacent positions were also observed but not taken into account for the contour map. The centre = -61°40′18″, taken from Hartley et al. Southern Dark Cloud Catalogue (1986) was defined as the coordinates' origin (0,0). The four corners of the observed main aria are coded as (-7,+5), (+1,+5), (+1,-1), and (-7,-1) separately (here minus means E or N, and each step is 3′ arc). Six minute integration at each position yielded an rms noise of 1.0 K. There were some interferences during observations. These made the rms noise larger than the normal. Observations of reference position were omitted as the line profile of the dark cloud is very sharp and the total bandwidth is low. The base line was extracted from both outer sections of the observed spectrum. The centre channel of the AOS (channel No. 487.5 during these observations) was set to the radial velocity of -4.0 kms^{-1} (LSR) which was taken from Goss et al. (1980). The methods of the observation and data processing have been described in a Coalsack study by Otrupcek and Wang (1987). The data processing was carried out by a newly installed VAX-8350 computer at Yunnan Observatory, Kunming.

3. RESULTS

The CO J=1-0 line was detected in most of the 72 observed positions. This region is a small portion of a large complex of dark clouds belonging to the Southern Coalsack. However, the available observing peroid on the 4-m telescope was restrictive and we were unable to continue observations to reach the bounds of CO emission. Also we were unable to confirm the exact extent of this molecular cloud. Nevertheless, the relative results still show something interesting.

Towards the optical centre position of the dark cloud DC 303.3+0.9 some weak CO emission appears around -4.0 kms^{-1} (LSR). But at N-E of 15 arcmin from the centre position the CO line shows a prominent double peak structure. Figure 1 shows the CO J=1-0 line profile averaged from 25 positions. The 25 positions were contained within a square area. The four corners of this square were defined by coordinates codes of (- 7,+4), (-3,+4), (-3,0) and (-7,0) separately. In figure 1 the CO profile was split into two adjacent components. Comparing with its double gaussian fitting in figure 2, one can see both blue and red shifted wings overlapped on the outer slopes on the profile.

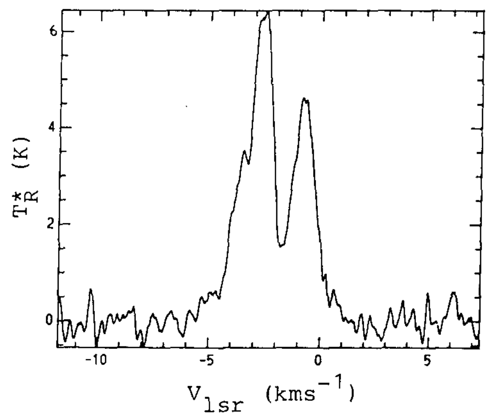

Figure 1. A double peak structure of CO J=1-0 line

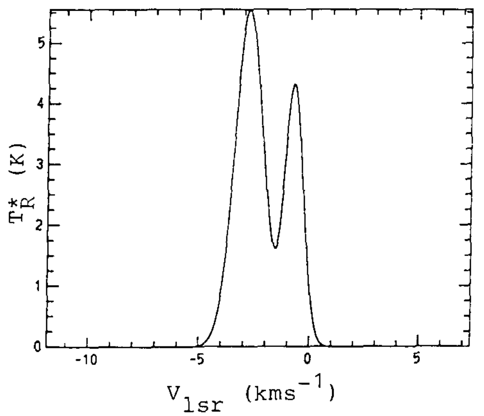

Figure 2. Double gaussian fitting of the CO profile

In figure 2 the gaussian fitted higher peask (i.e., the 'blue' one) is centred at the velocity of -2.8 kms^{-1}. The peak height of T_R^* is 5.5 K and the half width 1.5 kms^{-1}. The lower peak (the 'red' one) is centred at the velocity of -0.8 kms^{-1}. The peak height is 4.3 K and the half width 1.0 kms^{-1}.

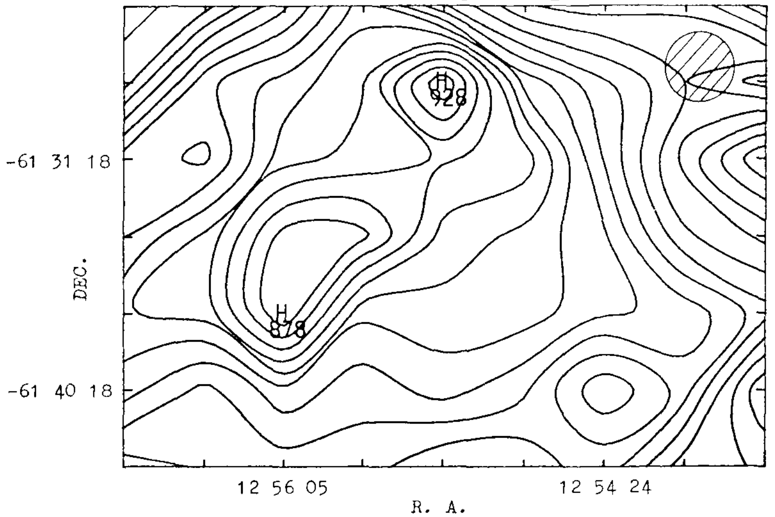

Figure 3. Contour map of the integrated temperature of the CO profiles

Figure 3 shows the contour map of the integrated temperature, $\int T_R^*$ dv, of CO J=1-0 line profile within the $27' \times 21'$ observed area. The integrating range of radial velocities (LSR) is between -5.4 kms^{-1} and +1.0 kms^{-1} covering both components. The interval between each two adjacent contours is 55 Kch. Here ch means an output channel that corresponds with 0.027 kms^{-1} in velocity. The symbol 'H' marks a local maximum at the unit of Kch. A circle shows the telescope beam (HPBW).

There appears a weak maximum at position (-1,0). It is coincident with the optical centre of DC 303.6+0.9 (0,0). But no evidence of a molecular cloud core was found.

To the north-east of the centre appears an elongated distribution along NW-SE direction. This area is consistent with the region in which profiles appear as double peaks. In order to examine the difference of distributions between the blue component and the red one, we made separate contour maps for both. The northern maximum (H 926) is coincident with both components in position (not shown in figure 4). But the other one (H 878) appears as a distinct bipolar diagram (shown in figure 4).

In figure 4 the solid contours show the blue component and the dashed lines show the red one. Assuming the boundary for the two components is at a velocity of -1.8 kms^{-1}, i.e. at the minimum between the two peaks, we take the integration ranges of velocities as (-6.4,-1.8) and (-1.8,+2.1) kms^{-1} for the blue and red ones separately. The interval in figure 4 is 36 Kch. The innermost contour level of the blue one is 648 Kch, of the red one 360 Kch. We did not reach the bounds of the cloud. The outer levels of the contour were omitted. The beam width is shown by a circle.

4. DISCUSSIONS

There are two possibilities for the explanation of the bipolar diagram:

(a) One possibility is that the two components are two independent molecular clouds situated, by chance, almost on the same radial direction. The 'blue' component has the radial velocity of

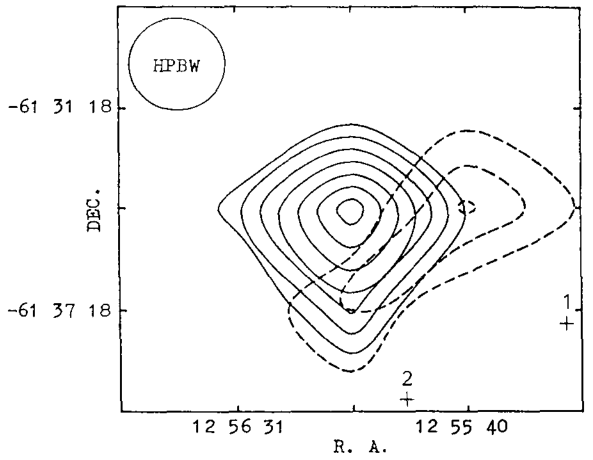

Figure 4. The bipolar diagram nearby DC 303.6+0.9

-2.8 kms^{-1} corresponding to a distance of r = 0.2 kpc estimated by menas of Oort formula. The 'red' one has the radial velocity of -0.8 kms^{-1} corresponding to a distance of 0.06 kpc. From an ESO J-plate we also see the optical extinction towards the direction of the 'blue' component is stronger than that towards the 'red' one.

(b) Another possibility is that there is a physical relation between the two components. From figures 3 and 4 one can see that the distribution of the two components is consistent with a NW-SE elongated region. Assuming the red component is at a similar distance than the blue one, i.e. about 0.2 kpc (this is perhaps acceptable considering the distance of the Coalsack, 0.18 kpc) from the Sun, the difference in velocity between the two components' is 2 kms^{-1}. The total size of this bipolar structure is about 0.5 pc. These are roughly consistent with a bipolar molecular outflow.

The positions of nearby IRAS point source are marked by crosses in figure 4. The color index of log $[F(12\mu m)/F(25\mu m)]$ for those sources are -0.27 (for No. 1 in figure 4, i.e. IRAS12554-6137) and -0.40 (for No. 2, i.e. IRAS12559-6140) respectively. We have not marked the position for IRAS source with positive color index within this region. Both IRAS sources are off the centre of the bipolar diagram. We guess source No. 2 may be more concerned. This bipolar diagram was made from separate integrations including each peak value. As the signal-to-noise ratio was not good enough to investigate the wings in detail, we can not conclude whether a bipolar molecular outflow is acutally there at the moment. Some further observations for this area are necessary.

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REFERENCES

de Vries, C.P., Brand, J., Israel, F.P., de Graauw, Th., Wouterloot, J.G.A., van de Stadt, H. and Habing, H.J. 1984, Astron. Astrophys. Suppl. Ser. 56, 333.

Fukui, Y., Sugitani, K., Takaba, H., Iwata, T., Mizuno, A., Ogawa, H. and Kawabata, K. 1986, Astrophys. J. Lett. 311, L85.

Goss, W.M., Manchester, R.N., Brooks, J.W., Sinclair, M.W. and Manefield, G.A. 1980, Mon. Not. Roy. Astron. Soc. 191, 533.

Hartley, M., Manchester, R.N., Smith, R.M., Tritton, S.B. and Goss, W.M. 1986, Astron. Astrophys. Suppl. Ser. 63, 27.

Huggins, P.J., Gillespie, A.R., Sollner, T.C.L.G. and Phillips, T.G. 1977, Astron. Astrophys. 54, 955.

Kutner, M.L. and Ulich, B.L. 1981, Astrophys. J. 250, 341.

Myers, P.C., Linke, R.A. and Benson, P.J. 1983, Astrophys. J. 264, 517.

Otrupcek, R.E. and Wang, J.-S. 1987, Proc. Astron. Soc. Aust. 7, 194.

Robinson, B.J., McCutcheon, W.H. and Whiteoak, J.B. 1982, Int. J. Infrared Millimetre Waves 3, 63.

Snell, R.L., Loren, R.B. and Plambeck, R.L. 1980, Astrophys. J. 239, L17.

Ulich, B.L. and Haas, R.W. 1976, Astrophys. J. 236, 192.

Wang, J.-S. and Otrupcek, R.E. 1987, Acta Astron. Sinica 28, 95.

Wang, J.-S., Robinson, B.J., Huang, G.-C. and Otrupcek, R.E. 1987, in Astrochemistry (IAU Symp. 120), Reidel, Dordrecht, 135.

Wang, J.-S. and Otrupcek, R.E. 1988, Vistas in Astron. 31, 493.

Wang, J.-S., Robinson, B.J., Huang, G.-C. and Otrupcek, R.E. 1989, Proc. Astron. Soc. Aust., in press.

Discussion:

HAYASHI: What is the linear scale of the structure which looks like a bipolar "outflow", (and how large is the velocity gradient)? If there is uncertainty about the distance, please give the number in arcminutes and $kms^{-1}(arcmin)^{-1}$.

WANG: The projected linear scale of the bipolar structure is about 9 arcmin, i.e. about 0.5 pc assuming the distance is $\sim$0.2 kpc from the sun (estimated from Oort formula). The velocity differences between the blue peak and the red one show a gradient of about 1 $kms^{-1}pc^{-1}$ from north to south.