HAT CREEK HCO+ AND HCN OBSERVATIONS OF SGRA

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ABSTRACT. We report aperture synthesis observations of the HCO+ and $H^{13}CN$ J=1-0 molecular lines towards the Galactic center. These data complement existing HCN data and trace a dense molecular ring surrounding the ionized central 2 pc of the Galaxy. The new data are consistent with the model of a clumpy, almost complete ring which is inclined to the line of sight at 50 to 75 degrees. The same structure is seen in HCO+ and in HCN with the exception of an HCN feature at 60 to 100 km/s in the western part of the ring, which is not detected in HCO+ emission. The HCN and HCO+ are collisionally excited in clumps with densities around 10^5 cm^{-3} and volume filling factor 1/3 to 1/30. $H^{13}CN$ emission from the ring was detected at about 1/7 of the intensity of the HCN; the latter is optically thick and is mapping a combination of surface density and excitation temperature. The HCO+ emission shows deep absorption features associated with galactic structure along the line of sight. Absorption features corresponding to the 3 kpc arm, the inner disk and an expanding ring at -195 km/s can be seen in absorption against the Sgr A radio continuum.

OBSERVATIONS

The data were obtained in 1988 April-July with the 3-element interferometer at the Hat Creek Radio Observatory. Observations of a single 2.'3 field centered on SgrA* were made at 18 baselines with spacings from 1500 to 50000 wavelengths. The spectral line data were obtained using a 512 channel digital correlator. The HCO+ line was recorded in the upper sideband of the first local oscillator; the $H^{13}CN$ line in the lower sideband. Both lines were Doppler tracked. The velocity resolution is 4 km/s with a total coverage from -500 to +500 km/s. The radio continuum for each sideband was estimated by averaging data with velocities outside of +/- 250 km/s. Spectral line maps were made from -200 to 200 km/s by subtracting the continuum and cleaning the resulting maps. With natural weighting, the synthesised beamwidth was 12."8 x 7."4. Structures larger than 1' in size are partially resolved in the maps presented.

DISCUSSION

Figure 1 compares the velocity-integrated HCO+ and HCN emission. The HCN, mapped with 2."2 spatial resolution, shows a very clumpy structure. The clumps are mostly resolved with sizes around 10". The HCO+ data closely follows the HCN emission; evidently the HCO+ comes from the same volume of gas as the HCN and is not enhanced by shocks or uv radiation at the inner edge of disk. The HCN and HCO+ are collisionally excited. Genzel et al. (1985) and Harris et al. (1985) deduce densities of 10^5 cm^{-3} from far-infrared and submillimeter

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line emission in the molecular ring. At these densities, HCN and HCO+ are subthermally excited with excitation temperatures of 3 to 10 K, of the same order as seen in the 2" resolution HCN data. The hydrogen column density in the HCN and HCO+ emitting gas is 10^{22} to 10^{23} cm^{-2}. The thickness of ring varies from 0.5 at the inner edge to 1.5 pc so that the volume filling factor is 1/3 to 1/30. Ionizing radiation can penetrate deeply into the molecular ring and may also provide excitation for hot H_2 emission seen from the same region (Gatley et al. 1986)

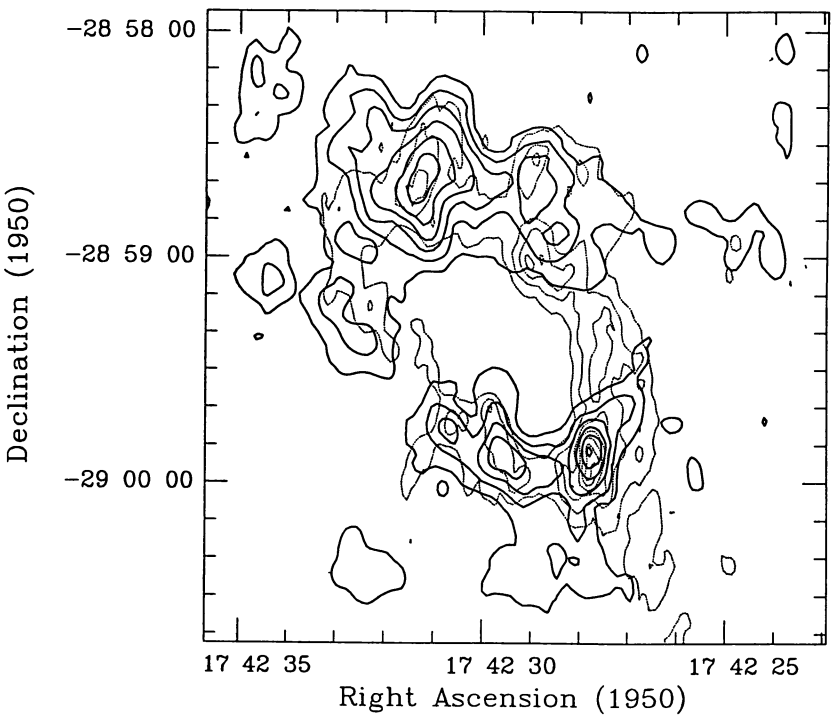

Figure 1. Comparison of the molecular ring mapped in HCN and HCO+. Velocity-integrated HCN (dotted contour interval 40 K km/s), and HCO+ (solid contour interval 24 K km/s)

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With the exception of the gap in HCO+ emission on the western side of the ring, the locations and velocities of the major peaks in HCN and HCO+ agree. Inspection of the spectra on the western side of the ring show that most of the HCN emission comes from a feature at 60-100 km/s which does not fit the rotation pattern of the rest of the ring (Guesten et al. 1987). This feature is not present in HCO+. (Figure 2)

The HCN and HCO+ spectra have comparable brightness. The $H^{13}CN$ brightness at the peaks of the HCO+ and HCN distribution is 1/4 to 1/7 of the brightness of the HCN and is below the noise level elsewhere in the ring. The $^{12}C/^{13}C$ ratio is observed to be 20 to 30 in the galactic center region (e.g., Wannier and Linke 1978), so that the HCN peaks have optical depths of 3-6. Because of the low filling factor of the dense (10^5 cm^{-3}) gas the HCN and HCO+ maps trace a combination of excitation temperature, column density and volume density in the molecular ring. In the south part of the ring the HCO+ spectra have many deep absorption features and are ~ 1/2 the brightness of the HCN.

The absorption profile seen in HCO+ against the galactic center is shown in Figure 2. The saturated absorption from -10 to +50 km/s is due to gas throughout the galaxy. The absorption in HCO+ is more complete than in HCN. Narrow features at -30, and -55 km/s correspond to the 3 kpc arm. The absorption at -135 km/s (the "expanding molecular ring") is also visible in single dish HCO+ profiles towards Sgr A and Sgr B2 (Linke et al. 1981), and has been interpreted in terms of a rotating expanding disk, 3 kpc in diameter and tilted at 20 degrees to the plane (Burton and Liszt 1978, Liszt and Burton 1978). The absorption seen in HCO+ at -175 and -195 km/s and extending to -210 km/s has also been observed in H_2CO and HI (Guesten and Downes 1981), and has been interpreted as expanding gas which has been expelled from the galactic center (e.g. Oort 1977). The expulsion of 5-10 10^6 solar masses of gas from the galactic center some 10^6 to 10^7 years ago has been suggested to explain the expanding molecular gas. Guesten et al. (1987) propose a more recent ($< 10^5$ yr) explosion in order to explain the short dynamic lifetime and sharp inner edge of the molecular ring.

REFERENCES

Burton, W.B., and Liszt, H.S., 1978, Ap.J. 225, 815.
Gatley, I, Jones, T.I., Hyland, A.R., Wade, R., Geballe, T.R., and Krisciunas, K., 1986, M.N.R.A.S., 222, 299.
Genzel, R., Watson, D.M., Crawford, M.K., and Townes, C.H., 1985, Ap.J., 297, 766.
Guesten, R., and Downes, D., 1981, Astr. Ap. 99, 27.
Guesten, R., Genzel, R., Wright, M.C.H., Jaffe, D.T, Stutzki, J., and Harris, A., 1987, Ap.J. 318, 124
Harris, A.I., Jaffe, D.T., Silber, M., and Genzel, R., 1985, Ap.J. (Letters) 294, L93.
Liszt, H.S., and Burton, W.B., 1978, Ap.J. 226, 790.
Oort, J.H., 1977, Ann. Rev. Astr. Ap., 15, 295.
Wannier, P.G., and Linke, R.A., 1978, Ap.J., 226, 817.

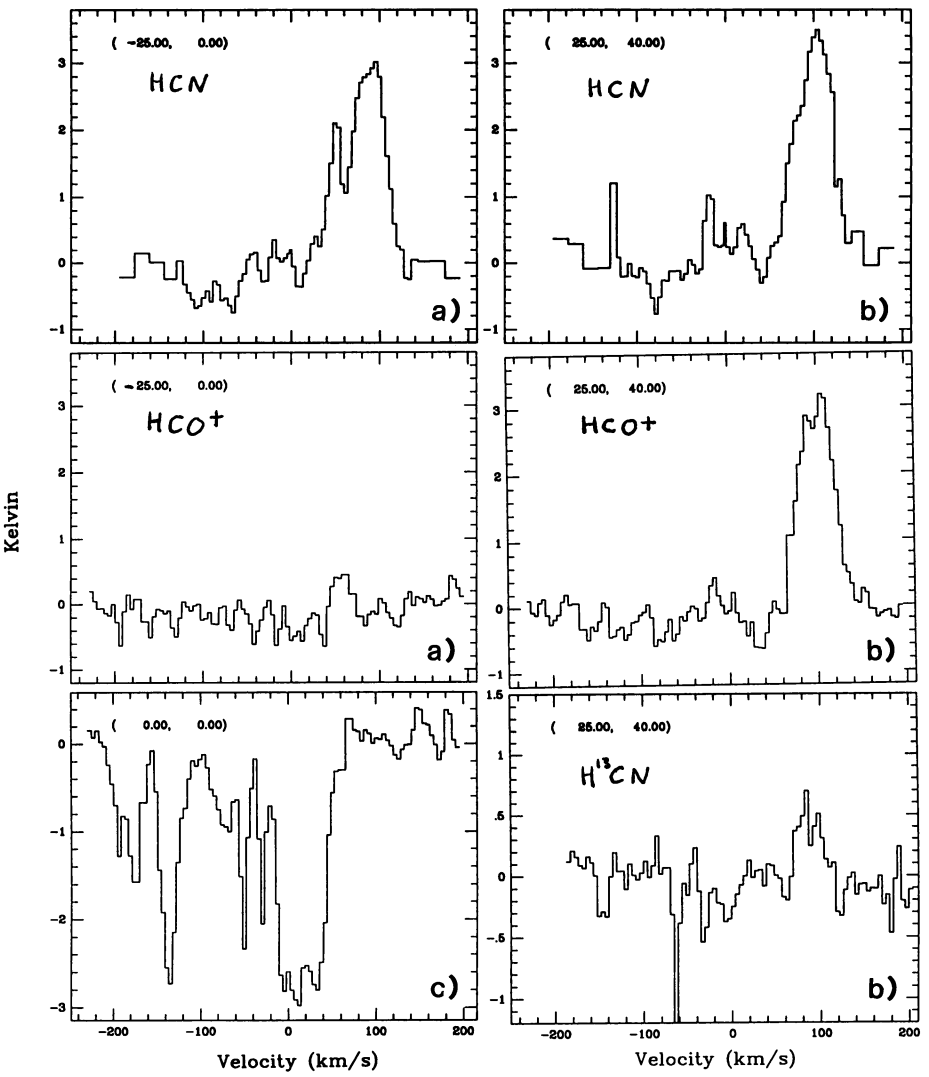

Figure 2. a) Comparison of HCN, and HCO+ spectra 25" west of SgrA* showing the extra feature at 80 km/s in HCN emission.
b) HCN, HCO+ and $H^{13}CN$ spectra at a position 25" east and 40" north from SgrA*.
c) HCO+ absorption against SgrA* at at 10" angular and 4 km/s velocity resolution. All spectra are convolved to 10" angular and 4 km/s velocity resolution.

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