1.0 mm CONTINUUM OBSERVATIONS OF COOL SOUTHERN CLOUDS

D.Y. Gezari, L. Cheung, and M.G. Hauser
Infrared and Radio Astronomy Branch (Code 693.2)
NASA/Goddard Space Flight Center, Greenbelt, MD. 20771

J.A. Frogel
Cerro Tololo Inter-American Observatory, La Serena, Chile

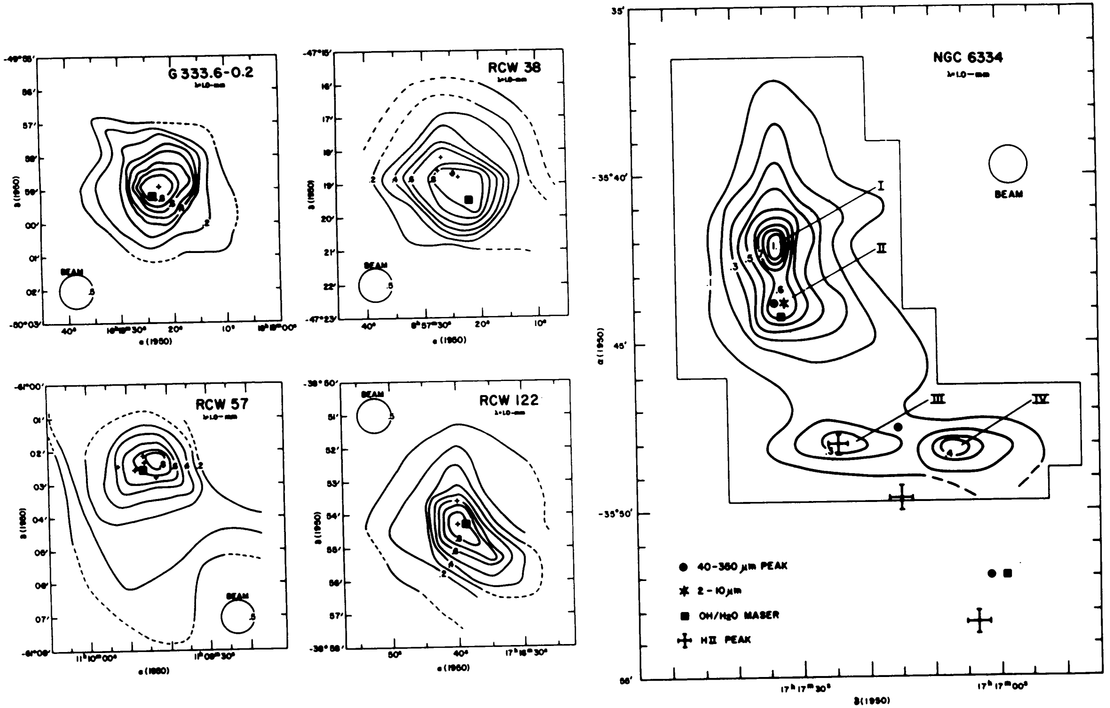
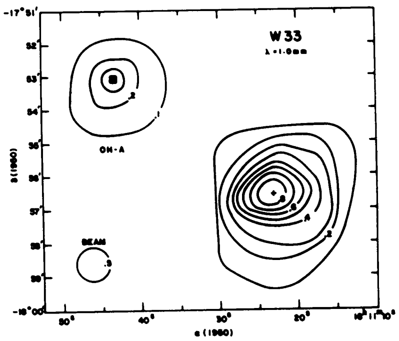
High surface brightness 1.0 mm continuum emission has been mapped in nine southern hemisphere HII/molecular cloud complexes: NGC 6334, RCW 38, RCW 57, RCW 122, RCW 117, G333.6-0.2, G351.6-1.3, W 33 and W 33A. All of the sources are located in the inner part of the Galaxy near the galactic plane. This paper presents new 1.0 mm continuum mapping results with 65 arc sec resolution. A more detailed discussion of the observations is given by Cheung et al. (1978, 1979).

All known 1 mm continuum dust emission sources are optically thin. The intensity of the 1 mm emission is proportional to the product of temperature and column density of the dust grains in the line of sight (for $T_d > 25K$). Therefore these 1.0 mm continuum observations provide a direct probe of the distribution of matter in dense molecular clouds. The sources presented here have a narrow range of dust density, linear extent, total mass and infrared luminosity. In most cases, the dust clouds are singly peaked and centered about one or more compact near-infrared sources (NGC 6334/I being the notable exception). We find in most sources a fairly steep gradient in the dust distribution around the central peaks consistent with a radial density distribution function of about $\rho(r) \propto r^{-1.5}$ (see Cheung et al. 1979 for a detailed analysis), and comparable to profiles of other known extended 1-mm continuum sources.

The derived average temperature for the region outside the central sub-arc-minute peak may be obtained from a two parameter fit to the observed 40-350 μm to 1 mm flux ratio (Cheung et al. 1978). This quantity is useful since the dust temperature in a centrally heated molecular cloud is expected to fall off slowly with radial distance, $T(r) \propto r^{-0.4}$ (Scoville and Kwan 1976). Not more than one third of the 1.0 mm flux in the central 1 arc min core, or 10% of the total map, can be attributed to free-free emission, as determined by a smooth extrapolation of the radio continuum observations. The derived dust temperatures are generally higher than the observed ^{12}CO antenna temperatures measured with similar beam size (Gillespie et al. 1977), in qualitative agreement with the picture that the molecular gas is collisionally heated by dust grains.

B. H. Andrew (ed.), Interstellar Molecules, 129–132.
Copyright © 1980 by the IAU.

https://doi.org/10.1017/S0074180900072387 Published online by Cambridge University Press

Figures 1-6: 1.0-mm continuum maps of six southern H II/molecular cloud complexes with 65 arc sec (FWHP) resolution. Squares indicate OH/H_2O maser sources, small crosses are 2-20μ sources, large crosses are compact H II peaks. All six objects are ^{12}CO sources. Each map is normalized to the peak flux density listed in the table. The statistical error is less than 5% of the peak; absolute calibration uncertainty is about 20%.

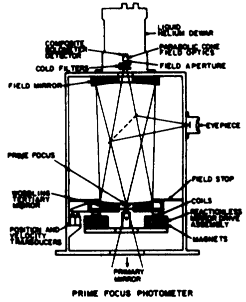


Figure 7: Remote controlled prime focus photometer (Gezari 1978) used at the CTIO 4-meter telescope. The liquid helium cooled composite bolometer (Hauser and Notarys 1975) was fabricated by our group, and consists of an indium doped germanium thermometer attached to a 2 mm square bismuth coated diamond wafer substrate, with an electrical NEP = 8 x 10^{-15} $WHz^{-1/2}$ at 1.4K. The square wave driver is essentially vibrationless.

https://doi.org/10.1017/S0074180900072387 Published online by Cambridge University Press

1.0 mm CONTINUUM OBSERVATIONS AND RESULTS

Object		Peak Position		1.0 mm Flux Density		Derived Results		Distance†	Calculated Cloud Properties		
		α(1950)	δ(1950)	Peak§ 65" FWHP (Jy)	Total Map (Jy)	T_{dust}** (K)	D_{dust}§ (gm cm-2)	(kpc)	M_{gas}‡ ($M_\odot$)	N_{H_2}§ (cm^{-2})	n_{H_2}§ (cm^{-3})
NGC 6334	*	$17^h17^m32.5^s$	-35°42'00"	132	2×10^3	25	4×10^{-2}	1.7	4×10^4	1×10^{24}	3×10^6
RCW 38	*	$08^h57^m20\overset{s}{.}9$	-47°18'50"	128	2×10^3	30	3×10^{-2}	1.5	3×10^4	8×10^{23}	6×10^5
RCW 57	*	$11^h09^m43\overset{s}{.}9$	-61°02'09"	146	1×10^3	-	2×10^{-2}	3.6	9×10^4	8×10^{23}	2×10^5
G333.6-0.2	*	$16^h17^m23\overset{s}{.}0$	-49°58'54"	139	7×10^2	35	2×10^{-2}	4.5	1×10^5	6×10^{23}	1×10^5
RCW 117	*	$17^h06^m01\overset{s}{.}5$	-41°32'20"	31	-	-	6×10^{-3}	4	-	2×10^{23}	5×10^4
RCW 122	*	$17^h16^m40\overset{s}{.}1$	-38°54'18"	53	3×10^2	35	8×10^{-3}	5	5×10^4	2×10^{23}	5×10^4
G351.6-1.3		$17^h25^m53\overset{s}{.}0$	-36°37'49"	42	-	-	8×10^{-3}	-	-	2×10^{23}	-
W 33		$18^h11^m18\overset{s}{.}1$	-17°56'28"	132	5×10^2	-	2×10^{-2}	4.6	7×10^4	7×10^{23}	2×10^5
W 33A		$18^h11^m43\overset{s}{.}7$	-17°53'02"	41	1×10^2	-	8×10^{-3}	4.6	2×10^4	3×10^{23}	6×10^4

* **^{12}CO observations exist for these objects, see Gillespie *et al*. 1977, Dickel *et al*. 1977, Scoville and Wannier (1977)**

** **Dust temperature derived assuming emissivity $\epsilon_\nu \propto \nu^1$** (Gezari *et al*. 1973) for those objects with known 100μ fluxes (Furniss *et al*. 1975).

† **Distances from Neckle (1978), Radhakrishnan *et al*.** (1972), Goss *et al*. (1972).

§ **Peak values, in 65 arc sec (FWHP) beam.** Values for sources without derived temperatures are calculated assuming $T_{dust} = 40K$.

‡ Total mass within 0.1 contour.

https://doi.org/10.1017/S0074180900072387 Published online by Cambridge University Press

The dust column density D along a line of sight through the dust cloud can be inferred from the relation $D = (4/3)\rho_d\tau/(Q/a)$, where ρ_d is the mass density of dust grains with radius a and 1 mm extinction efficiency Q. τ is the optical depth, which is derived from the observed 1-mm flux density S_ν and the derived grain temperature T_d. To calculate the results in the table we adopt for all the sources the nominal values $Q/a = 1\ \mathrm{cm}^{-1}$ (Aannested 1975), $\rho_d = 1\ \mathrm{gm\ cm}^{-3}$, $m_{gas}/m_{dust} = 100$, and spherical source geometry.

The sources W 33A and NGC 6334/I appear to be sites of star formation in its early stages. In contrast to W 33, W 33A is unresolved at 1.0 mm and coincident with an OH emission line source, but shows no radio continuum emission in high resolution interferometric observations (Goss et al. 1978). NGC 6334/I, the strongest peak of 1.0 mm emission, coincides roughly with the extended 40-350μ plateau, but is not associated with any other known compact emission object.

The similarity in mass distribution between these southern clouds and other known 1 mm continuum sources, which differ greatly from our sample in mass, linear extent and infrared luminosity (OMC-1, Sgr B2, W 3, W 49, DR 21, and W 75 - Westbrook et al. 1977) provides further support for the suggestion that extended dust clouds with compact energetic luminosity sources form by a rather general physical process.

REFERENCES

Aannestad, P.A.: 1975, Astrophys. J. 200, 30.

Cheung, L., Frogel, J.A., Gezari, D.Y., and Hauser, M.G.: 1978, Astrophys. J. (Letters) 226, L149.

Cheung, L., Frogel, J.A., Gezari, D.Y., and Hauser, M.G.: 1979, (in preparation).

Dickel, H.R., Dickel, J.R., and Wilson, W.J.: 1977, Astrophys. J. 217, 56.

Furniss, I., Jennings, R.E., and Moorwood, A.F.M.: 1975, Astrophys. J. 202, 400.

Gezari, D.Y.: 1978, (preprint).

Gezari, D.Y., Joyce, R.R., and Simon, M.: 1973, Astrophys. J. (Letters) 179, L67.

Gillespie, A.R., Huggins, P.J., Sollner, T., Phillips, T.G., Gardner, F.F., and Knowles, S.H.: 1977, Astron. Astrophys. 60, 221.

Goss, W.M., Matthews, H.E., and Winnberg, A.: 1978, Astron. Astrophys. 65, 307.

Goss, W.M., Radhakrishnan, V., Brooks, J.W., and Murray, J.D.: 1972, Astrophys. J. Suppl. 24, 123.

Scoville, N.Z., and Kwan, J.: 1976, Astrophys. J. 206, 718.

Scoville, N.Z., and Wannier, P.G.: 1977, Proc. IAU/URSI Symposium (19th COSPAR Plenary) 63, D. Reidel Pub. Co., Holland, 77.

Shaver, P.A., and Goss, W.M.: 1970, Aust. J. Phys. Suppl. 14, 133.

Westbrook, W.E., Werner, M.W., Elias, J.H., Gezari, D.Y., Hauser, M.G., Lo, K.Y., and Neugebauer, G.: 1976, Astrophys. J. 209, 94.

https://doi.org/10.1017/S0074180900072387 Published online by Cambridge University Press