NASA TM-88185

NASA Technical Memorandum 88185

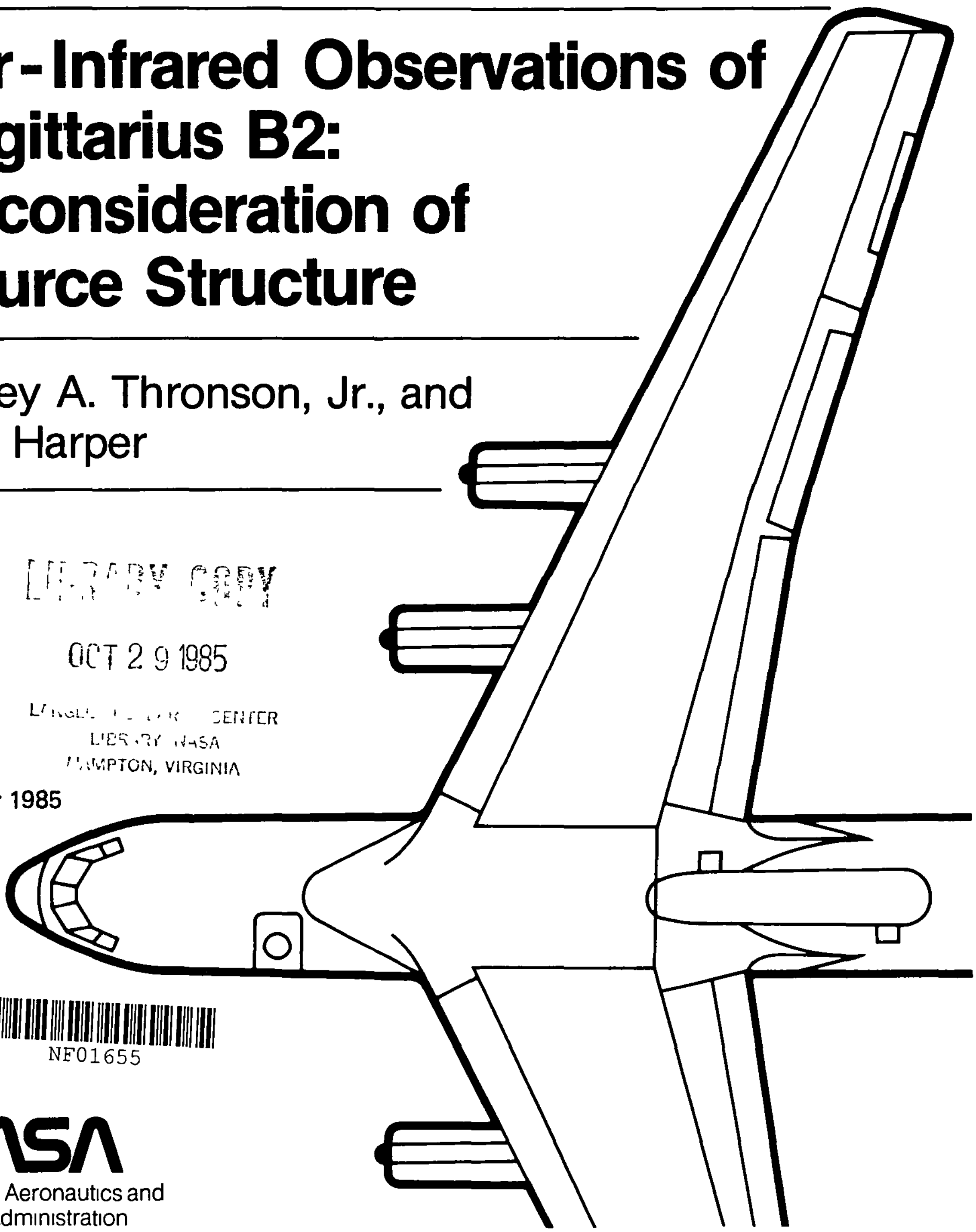
Airborne Astronomy Program
Medium Altitude Mission Branch
Preprint Series 039

NASA-TM-88185
19860002700

Far-Infrared Observations of Sagittarius B2: Reconsideration of Source Structure

Harley A. Thronson, Jr., and
D.A. Harper

October 1985



NASA
National Aeronautics and
Space Administration

NASA Technical Memorandum 88185

Airborne Astronomy Program
Medium Altitude Mission Branch
Preprint Series 039

Far-Infrared Observations of Sagittarius B2: Reconsideration of Source Structure

Harley A. Thronson, Jr., Wyoming Infrared Observatory, University of Wyoming, Laramie, Wyoming
D. A. Harper, Yerkes Observatory, University of Chicago, Williams Bay, Wisconsin

October 1985

NASA
National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035

N86-12167#

ABSTRACT

New moderate-angular-resolution far-infrared observations of the Sagittarius B2 star-forming region are presented, discussed, and compared with recent radio molecular and continuum observations of this source. In contrast to previous analyses, we interpret its far-infrared spectrum as the result of a massive frigid cloud overlying a more-or-less normal infrared source, a natural explanation for the object's previously-noted pecularities. The characteristics derived for the obscuring cloud are similar to those found for the W51 MAIN object. Both sources have high sub-millimeter surface brightness, a high ratio of sub-millimeter to far-infrared flux, and numerous regions of molecular maser emission.

Subject headings: Infrared: General -- Infrared: Sources -- Infrared: Spectra -- Nebulae: Individual

I. INTRODUCTION

Sagittarius B2 is one of the most luminous star-forming regions in the Galaxy. Because of this, and because of its proximity to the Galactic Center, it has been the subject of numerous programs of infrared and radio molecular study.

Because the source suffers such heavy extinction, it is very weak at wavelengths shortward of about 30 μm (Becklin et al. 1977; R. Gehrz, private communication) and infrared continuum studies have therefore emphasized wavelengths accessible from aircraft altitudes (Harper 1974; Harvey, Campbell, and Hoffmann 1977 [hereafter HCH]; Erickson et al. 1977 [hereafter EEA]; Gatley et al. 1978 [hereafter GEA]). The far-infrared source is centered on a small group of bright radio continuum H II regions. Of particular curiosity is the "cool" dust temperatures derived by these authors: typically T_d = 35 K, about a factor of two less than values found for other equivalently luminous star-forming regions.

Radio molecular observations, on the other hand, have usually shown warm gas (e.g., Zuckerman et al. 1971; Scoville, Solomon, and Penzias 1975; Hollis et al. 1981; Churchwell and Hollis 1983; Cummins et al. 1983; Vanden Bout et al. 1983; Kuiper et al. 1984). Gas temperatures deduced from different molecular species often refer to different locations within a source so some variations in calculated values are expected. For Sgr B2, detailed, recent analyses give gas temperatures in the range 40-60 K, although some higher and lower values have been suggested. The source is unique, therefore, in having gas kinetic temperatures much greater than the derived dust temperature, in disagreement with the predictions of molecular heating via gas-dust thermal coupling. It was this apparent contradiction that prompted, first, a re-observation of Sgr B2 at far-infrared wavelengths and, second, a reconsideration of the technique of calculating dust temperatures from photometric data.

In this paper we present new far-infrared photometry and mapping of the Sgr B2 source. Our observations are compared with other far-infrared data. We discuss the apparent low dust temperature in the object and the effect of extinction on the interpretation of far-infrared data.

II. OBSERVATIONS

The observations reported here were obtained using the 0.9 m telescope onboard the NASA Kuiper Airborne Observatory. Results are presented in Figure 1 and Table 1. Detector and filter systems are described in Loewenstein _et al._ (1977) and Thronson and Harper (1979). Most of the apertures were chosen to obtain approximately the highest angular resolution possible with this telescope at each wavelength. Broadband fluxes were converted to flux densities in an iterative manner similar to that described by Thronson and Harper. Jupiter was used for absolute calibration, adopting the infrared brightness temperatures presented in Loewenstein _et al._ The reference beam separation was 4.'5 for the 30"-resolution observations and 6' at the other resolutions. The orientation of the chopper throw was approximately east-west and the 1σ absolute positional accuracy was approximately ±10". Relative positional uncertainties of points that make up the maps are approximately ±4". Photometry of the peak was obtained with three filters in addition to those used to produce the figures. Integrated flux densities are given in Table 1. Because our map obtained at 220 μm is incomplete, we do not estimate a total flux density at that wavelength. Each map was produced by sampling every half-resolution element. For the three shorter-wavelength maps an area about the size of the 166 μm emission was scanned to produce the maps. An area only slightly larger than that shown in the 220 μm figure was scanned to produce that figure.

Although we did not attempt to observe the source with identical beam sizes at all wavelengths, the integrated flux densities from the Figure 1 maps may be used to estimate a source luminosity. For a distance of 10 kpc, we found $L = 7 \times 10^6 L_\odot$ for $\lambda = 30\ \mu m - 300\ \mu m$. This is in agreement with other far-infrared observations and confirms that the source is one of the most luminous objects in the Galaxy.

III. ANALYSIS AND DISCUSSION

a. Source Structure and Comparisons with Previous Observations

At 60 μm Sgr B2 appears sharply peaked close to the position of radio continuum source number 5, the second brightest radio H II region in Martin and Downes (1972; see also Rogstad, Lockhart, and Whiteoak 1974; Balick and Sanders 1973). Within the uncertainties, all the far-infrared observations obtained to date show a maximum at the same position, with much less emission coming from a brighter radio continuum source (number 4 in Martin and Downes) about 50" north of source number 5. Radio molecular maps (Scoville, Solomon, and Penzias 1975; Morris *et al.* 1976; Churchwell and Hollis 1983) show the highest temperature gas toward the far-infrared peak. Sgr B2 therefore appears very similar to many active, luminous star-forming regions.

Since a number of far-infrared observations of Sgr B2 have been reported, it's useful to summarize a comparison between our results and those of others. At 30" resolution, the quoted flux densities in HCH are in good agreement with our data, when corrected for modest wavelength differences. However, at about 1' resolution, the photometry of HCH disagrees substantially with the results in Table 1 in that our 61 μm value is much lower and our 166 μm value is much higher than would be found from the spectrum presented in HCH. It is likely that this disagreement is due to the data reduction technique employed by HCH to correct their data to a standard set of beam sizes.

Erickson et al. presented a high-resolution spectrum of Sgr B2 taken with a 1!4 beam. Our 220 μm observation agrees well with that of EEA. In addition, the shape of their far-infrared spectrum agrees well with that deduced from our photometry, although the absolute values disagree due to beam size effects. Since the source is so centrally concentrated to 1-2 arcmin beams, it is difficult to discern the effects of radial temperature gradients from multi-aperture data. Thus, spectral shapes may not change much with beam size.

Comparing our observational data with that of GEA, we find that their observed flux densities are about 40% greater than ours at all wavelengths. This is within the combined uncertainties of both sets of data. At 50 μm, GEA report the peak flux density at a position 20" north of our maximum, just within the quoted uncertainties.

b. The Dust Emission

The far-infrared spectrum of Sgr B2 is unique as this is the only highly luminous star-forming region that appears to have cold dust ($T_d \stackrel{<}{\sim} 35$ K) close about embedded stars. Some, although not all, early radio molecular observations indicated that the gas kinetic temperatures in the source satisfied $T_k \stackrel{<}{\sim} T_d$, as expected for a region in which the gas is heated by collisions with the dust grains. However, more recent and more detailed work suggests that, in fact, $T_k = (1\text{-}2) \times T_d$ (see references in the introduction). More recent observations have generally concentrated on higher-dipole-moment molecules that are likely to be excited in the more central regions of the cloud and more sophisticated analytical models for interpreting the data. These results may therefore more accurately reflect kinetic temperatures in the region of strongest dust emission. A gas kinetic temperature significantly greater than the dust temperature flatly contradicts the predictions of gas heating via collisions with dust grains and prompts us to examine the T_d deduced for Sgr B2 more carefully.

Additional information about the Sgr B2 complex has been provided by the recent high angular resolution radio continuum observations of Benson and Johnston (1984) of the compact H II regions which presumably power the far-infrared source. Most of the observed flux density comes from the components corresponding to sources 4 and 5 of Martin and Downes (1972). Benson and Johnston infer that the northern source (#4) has about twice the Lyman continuum luminosity of the southern (#5) object. Comparison with other luminous, compact star-forming regions (e.g., Thronson and Harper) suggests that on the basis of these radio observations, the northern object should be significantly brighter than the southern one in the 50-100 μm band, which Figure 1 shows is not the case.

Yet another peculiarity of Sgr B2 is its extremely high surface brightness at 300-400 μm, first noted by Rieke et al. (1973; see also Westbrook et al. 1976). After observations of many additional regions of star formation, Sgr B2 is still the brightest such source at sub-millimeter wavelengths. A recent observation that is relevant to our consideration of Sgr B2 is the 400 μm map of W51 by Jaffe, Becklin, and Hildebrand (1984). They concluded that the dominant structure at these wavelengths, W51 MAIN, is a dense, massive cloud that contains $\sim 10^5$ $M_\odot$ of material. Moreover, this cloud is so cold that it was not found in observations of the region at about 60 μm.

We argue that the most plausible interpretation of the observations of Sgr B2 is as an analog of the W51 system seen from a different orientation. In W51 the most luminous H II region is W51 IRS 2, which is offset from the massive, frigid cloud (W51 MAIN) on the plane of the sky. If, instead, IRS 2 were located behind W 51 MAIN, it would suffer significant extinction, even at far-infrared wavelengths. Due to the absorbing cloud, the spectrum of the emitting region would appear "cool", although in fact the dust may be quite warm.

Further, the appearance of the underlying source can be significantly altered by variations in the overlying cloud. The H_2CO absorption observations of Fomalont and Weliachew (1972) and Rogstad, Lockhart, and Whiteoak (1974) show heavier absorption over the northern (#4) than over the southern (#5) source in Sgr B2. This would be a natural explanation for why our observations show the 60 μm emission maximum near the position of the weaker (southern) radio continuum source (Figure 1).

These formaldehyde observations may be roughly quantified by noting that the maximum H_2CO optical depth is $\sim$2.5. A relation between this optical depth and that of the 9.7 μm silicate feature has been suggested by Sarazin (1978), where $\tau(\text{silicate})/\tau(H_2CO) \stackrel{>}{\sim} 20$, meaning that the observed H_2CO absorption must be associated with a 100 μm absorption optical depth of nearly unity, since $\tau(\text{silicate})/\tau(100\ \mu m) \stackrel{<}{\sim} 50$.

Evidence for an extremely thick dusty cloud can further be found in the analyses of previous far-infrared observations of Sgr B2, although none of the earlier works considered the effects of an overlying, massive frigid cloud on the source spectrum, as we do here. Erickson et al. adopted a standard single-slab expression for thermal emission, $F_\nu \propto B_\nu(T_d)[1-e^{-\tau}]$, finding T_d = 32 K, with $\tau \stackrel{\sim}{\sim}$ 1-2 at 100 μm. Harvey, Campbell, and Hoffmann as well as Gatley et al., used an optically-thin approximation, $F_\nu \propto \nu B_\nu(T)$. The former authors calculated T_d = 35 K and $\tau \stackrel{\sim}{\sim} 1$ at 100 μm, while the latter found T_d = 32 K, with $\tau \stackrel{>}{\sim} 1$ at 50 μm. Preceding studies of Sgr B2, therefore, produced quite consistent results, concluding that the source spectrum arises from cool, optically-thick dust in emission.

With abundant evidence for large dust optical depth and gas temperatures greater than calculated dust temperatures, we feel that a simple alternative model for the far-infrared emission from Sgr B2 should be considered. Our attempt to improve the derived source parameters is to assume that in addition to emmision from the dust, the object is overlain by a second component to its structure: a massive frigid cloud that emits very little at the far-infrared wavelengths considered here.

Emission from an isothermal, two-slab, plane-parallel source under the assumptions adopted here is

$$F_\nu = \Omega B_\nu(T_d)\, \exp(-\tau_{\nu,a})[1 - \exp(-\tau_{\nu,e})],$$

where Ω is the beam solid angle, $\tau_{\nu,e}$ is the emission optical depth, and $\tau_{\nu,a}$ is the absorption optical depth of the overlying cloud. Over the wavelength range considered here we assumed $\tau \propto \nu^{1.5}$ for the wavelength dependence of both optical depths (see discussion in Hildebrand 1983). It must be emphasized that with appropriate values for the several variables, the functional form above can appear similar to the standard optically-thin blackbody emission model $[F_\nu \propto \nu B_\nu(T_d)]$ currently favored by astronomers analyzing far-infrared photometry. Inspection of most published spectra will not be able to reveal which function to use, but the deduced results are quite different. Consideration of other kinds of observationa data -- radio molecular observations, for example -- might be useful in determining which approximations are suitable for an individual object.

Because of the good wavelength coverage, we fit our model to the data in EEA, noting again that their observations are in agreement with ours. We attempted only a coarse grid of model parameters, but found a good fit for T_d = 80 K. The optical depths that gave the best fits were $\tau_{\nu,e} = 0.5(100\ \mu m/\lambda)^{1.5}$ and $\tau_{\nu,a} = 2.5(100\ \mu m/\lambda)^{1.5}$. Model spectra for F_ν were all within about 1σ of the observations for variations in T_d of $\sim \pm$ 15 K and in the optical depths of $\sim \pm$ 50%.

These variations were estimated while holding the other paramters constant. Calculated source parameters are presented in Table 1. The large uncertainty in τ_a is unfortunate and is a result of this parameter being sensitive to the short-wavelength end of the spectrum of EEA which has fairly high noise. Since the data to which our model was fit was from a large beam and thus included a number of distinct components, our results must be considered as rough averages for the region. It is nevertheless significant that our results are in better agreement with currently held views on star-forming regions than previous models for this object. The most satisfying result is that we find $T_d > T_k$, as predicted by theories of gas/dust thermal coupling. Accurate models of far-infrared emission are important since several source parameters are derived from dust temperatures: optical depths and dust masses, for example. Even very modest absorption, much less than that calculated for Sgr B2, can significantly alter these derived parameters because of their sensitive dependence upon T_d. For that reason, the usual single-slab model of far-infrared emision should not be applied indiscriminately.

Analyses of recent radio molecular observations (Vanden Bout _et al._ 1983, Churchwell _et al._ 1985) produce two-component models for Sgr B2 that, where comparable, are in agreement with that which we have proposed. Churchwell _et al._, for example, describe two temperature regimes in the source: gas with a fairly high kinetic temperature ($T_k \approx 70$ K), plus a second component with $T_k \approx 10$ K. Indeed, Sgr B2 appears to be the only strong radio molecular source that needs two components to explain its emission line spectrum. It requires, however, that the molecule being observed have several transitions, each sensitive to a different temperature or density, for this type of model to be produced.

c. Extinction Toward Sgr B2

The essential result of our model is the very large far-infrared absorption optical depth. Our calculated value means that the distribution of emission from the source at $\lambda \lesssim 200$ μm is largely determined by overlying extinction.

Despite the approximations of our model, we suggest that because of the particular structure of the Sgr B2 region, we may in fact have produced a reasonably accurate description. A number of authors (Gusten and Downes; Linke, Stark, and Frerking 1981) have attempted to describe the absorption around Sgr B2. Linke *et al.* estimated $N(H_2) \approx 5 \times 10^{23}$ cm^{-2} for overlying, cold extinction to the source, which leads to $A_V \approx$ 500 magnitudes, in fair agreement with our far-infrared model. Gusten and Downes suggest that the emitting source lies interior to an extensive ring of molecular gas surrounding the Galactic Center. In this description, Sgr B2 itself is not directly physically associated with the heavy overlying extinction and therefore is not heating it, in agreement with our assumptions.

We can take advantage of our estimate of the average overlying extinction (τ_a = 2.5 at 100 μm) to derive useful relations between dust optical depth and molecular column densities, being mindful that the far-infrared data came from a somewhat smaller beam size than did the radio data. Linke *et al*. calculated the column densities for three trace molecules toward Sgr B2. It is likely that these are associated with the non-emitting dust. If so, we find the following relations:

$$N(H^{13}CO^{+}) = 0.9 \times 10^{13}\,\tau_{100}\ cm^{-2}$$
$$N(H^{13}CN) = 1.1 \times 10^{13}\,\tau_{100}\ cm^{-2}$$
and
$$N(HNC) = 2.6 \times 10^{13}\,\tau_{100}\ cm^{-2},$$
where τ_{100} is the dust optical depth at 100 μm.

One major consequence of the model proposed here is that the luminosities quoted for Sgr B2 from previous moderate-resolution far-infrared observations are too low by a significant factor. The uncertainty is large in our calculated far-infrared extinction, but we suggest that the luminosity estimated for Sgr B2 should be about a factor of 10 higher than usually quoted, or roughly $7 \times 10^{7}\ L_{\odot}$. Because of the heavy extinction, a large fraction of this luminosity should be emitted at wavelengths longward of 100 μm. Recently, Benson and Johnston (1984) identified compact radio H II regions in Sgr B2 that required an excitation equivalent to a stellar luminosity of 1.1×10^{7} $L_{\odot}$ and suggested a contribution of another $2.3 \times 10^{7}\ L_{\odot}$ necessary to account for diffuse emission. Previous analyses of far-infrared observations deduced luminosities factors of 3 to 10 below these values. Clearly, the luminosity of Sgr B2 has been underestimated in the past, but its exact value awaits more detailed work than we have attempted here.

IV. CONCLUSIONS

Four new far-infrared maps of Sagittarius B2 have been presented and discussed. We find that the object is powered by the equivalent of at least 5 O4 ZAMS stars, which makes the object one of the most luminous star-forming regions in our galaxy.

In light of new far-infrared, radio continuum, and molecular line data on Sgr B2, we have suggested an alternative model which accounts for many of the previously-noted peculiarities, in particular, the discrepancy between luminosities derived from radio and far-infrared data and the anomolously low dust temperatures. The model is based on an analogy with W 51, a source in which the brightest far-infrared/H II complex is slightly displaced from a massive frigid molecular cloud characterized by a high submillimeter surface brightness, high ratio of submillimeter to far-infrared flux, and the presence of a large concentration of molecular maser sources. In this picture, the massive core of the cloud may be heated only incidentally by the luminous H II regions and therefore emits very little at $\lambda \lesssim 200\ \mu m$. Absorption through the cloud is very high, leading to an underestimation of the source luminosity and temperature in a case like Sgr B2 in which the H II region is located behind the massive cloud. However, it is important to note that although the luminosity of the entire complex of sources in Sgr B2 could be 3-10 times larger than previously assumed, the cold absorbing cloud itself (as well as the one in W 51) is probably significantly underluminous compared to many other molecular clouds of comparable mass. Most far-infrared spectra alone are not of sufficient quality to allow a unique determination of the type of model to use to describe most source emission.

It may be useful to think of the dense molecular cores of Sgr B2 and W 51 MAIN as members of a distinct class of clouds, a class that has not been widely appreciated because they are so cold they are not detected by most far-infrared observations. As massive as they are, such objects could well be the progenitors of the most luminous

Galactic clusters. A better picture of how such objects are assembled from less dense material and how -- or if -- star formation proceeds within them would not only add to our knowledge of star formation processes in our own galaxy, but may be crucial for understanding the more luminous "starbursts" seen in other galaxies.

ACKNOWLEDGEMENTS

We are grateful to the ground and flight crew of the NASA Kuiper Airborne Observatory and the administration of the NASA Ames Medium Altitude Missions Branch. The referees made a number of useful suggestions that improved our presentation. This work was supported by NASA granst NAG 2-134 to the University of Wyoming and NGR 14-001-227 to the University of Chicago.

REFERENCES

Balick, B., and Sanders, R. H. 1974, Ap. J., 192, 325.

Becklin, E. E., Matthews, K., Neugebauer, G., and Wynn-Williams, C. G. 1977, Astr. Ap., 55, 19.

Benson, J. M., and Johnston, K. J. 1984, Ap. J., 277, 181.

Churchwell, E., and Hollis, J. M. 1983, Ap. J., 272, 591.

Churchwell, E., Myers, P., Myers, R.V., and Wood, D 1985, B.A.A.S., 17, 557.

Cummins, S. E., Green, S., Thaddeus, P., and Linke, R. A. 1983, Ap. J., 266, 331.

Erickson, E. F., Caroff, L. J., Simpson, J. P., Strecker, D. W., and Goorvitch, D., 1977, Ap. J., 216, 404 (EEA).

Fomalont, E. B., and Weliachew, L. N. 1973, Ap. J., 181, 781.

Gatley, I., Becklin, E. E., Werner, M. W., and Harper, D. A. 1978, Ap. J., 220, 822 (GEA).

Gusten, R., and Downes, D. 1980, Astr. Ap., 87, 6.

Harper, D. A. 1974, Ap. J., 192, 557.

Harvey, P. M., Campbell, M. F., and Hoffmann, W. F. 1977, Ap. J., 211, 786 (HCH).

Hildebrand, R. H. 1983, Q. J. R. A. S, 24, 267.

Hollis, J. M., Snyder, L. E., Blake, D. H., Lovas, F. J., Svenram, R. D., and Ulich, B. L. 1981, Ap. J., 251, 541.

Jaffe, D., Becklin, E. E., and Hildebrand, R. H. 1984, Ap. J. (Letters), 279, L51.

Kuiper, T. B. H., Rodriguez Kuiper, E. N., Dickinson, D. F., Turner, B. E., and Zuckerman, B. 1984, Ap. J., 276, 211.

Linke, R. A., Stark, A. A., and Frerking, M. A. 1981 Ap. J., 243, 147.

Loewenstein, R. F. , Harper, D.A., Mosely, S.H. Telesco, C., Thronson, H.A.,Jr., Hildebrand, R.H., Whitcomb, S.E., Winston, R., and Stiening, R.F., 1977, Icarus, 31, 315.

Martin, A. H. M., and Downes, D. 1972, Ap. Letters, 11, 219.

Morris, M., Turner, B. E., Palmer, P., and Thaddeus, P. 1976, Ap. J., 205, 82.

Rieke, G. H., Harper, D. A., Low, F. J., and Armstrong, K. R. 1973, Ap. J. (Letters), 183, L67.

Rogstad, D. H., Lockhart, I. A., and Whiteoak, J. B. 1974, Astr.Ap., 36, 253.

Sarazin, C. L. 1978, Ap. J., 220, 165.

Scoville, N. Z., Solomon, P. M., and Penzias, A. A. 1975, Ap. J., 201, 352.

Thronson, H. A., and Harper, D. A. 1979, Ap. J., 230, 133.

Vanden Bout, P. A., Loren, R. B., Snell, R. L., and Wootten, A. 1983, Ap. J., 271, 161.

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

Zuckerman, B., Morris, M., Turner, B., and Palmer, P. 1971, Ap. J. (Letters), 169, L105.

TABLE 1

Sgr B2 Source Parameters

a) Observed

Peak (60 μm; 30" Beam)		$\alpha(1950) = 17^h\ 44^m\ 10^s.2 \pm 1^s$ $\delta(1950) = -28°\ 22'\ 2'' \pm 10''$	
Flux Densities[a] (Jy)		Photometry at Peak Only (55" Beam	
	41 μm		1650±500
	61 μm		6200
		Peak	Total
	60 μm (30")	5100	10,000
	125 μm (55")	22,000	53,000
	166 μm (55")	27,000	63,000
	220 μm (1!9)	27,000	-
Luminosity[b] (30μm - 300 μm)		$7 \times 10^6\ L_\odot$	

b) Derived[c]

Dust Temperature of Core (K)	80 ± 15
Emission Optical Depth of Core	$0.5(100\ \mu m/\lambda)^{1.5}$ ± 50%
Absorption Optical Depth of Overlying Material	$2.5(100\ \mu m/\lambda)^{1.5}$ ± 50%

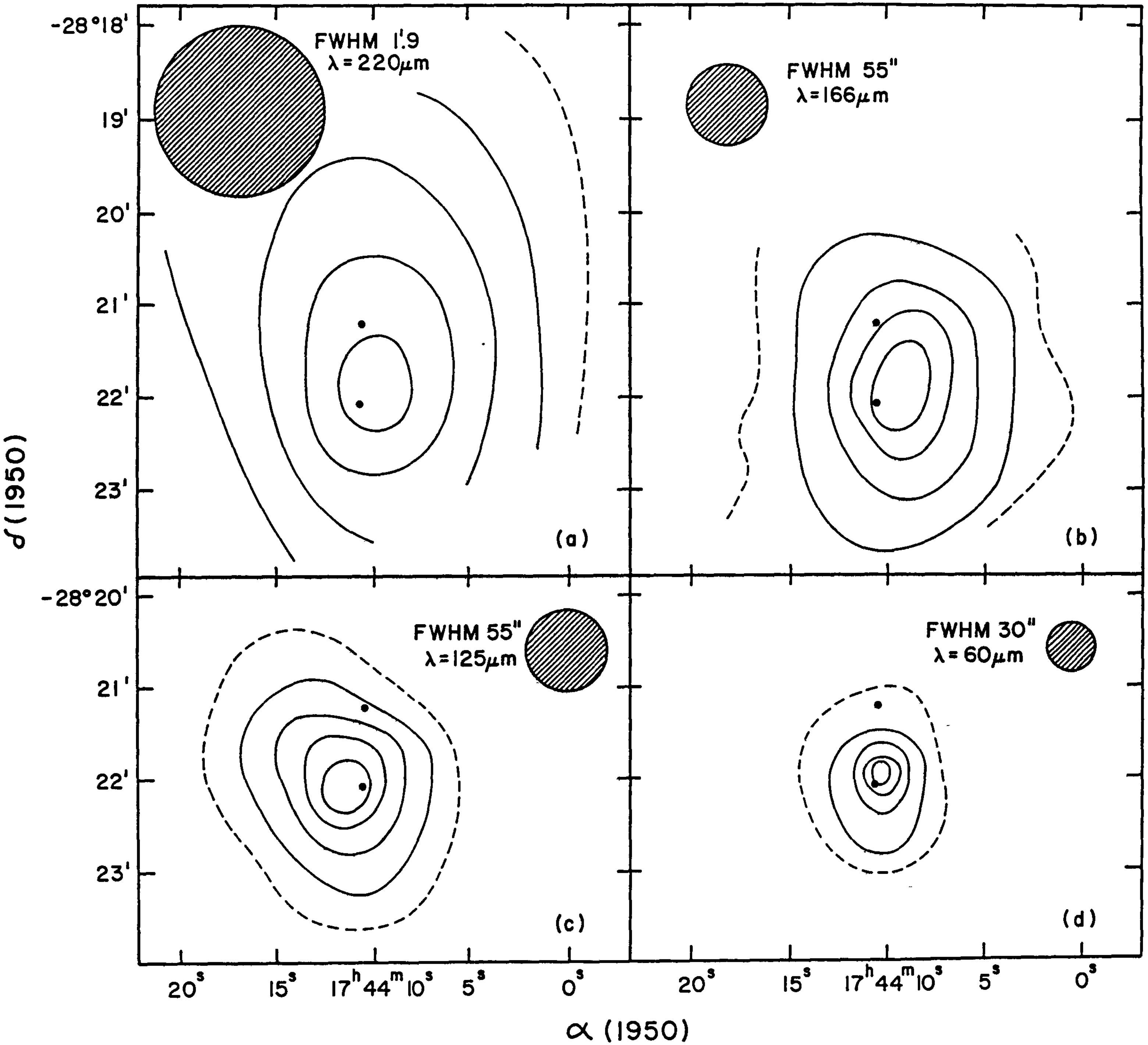
[a]Signal-to-noise ratio better than 20:1 unless noted; estimated total uncertainties are ± 20%.

[b]Probable lower limit due to heavy far-infrared extinction (§IIIb); distance assumed to be 10 kpc.

[c]Based on model described in § IIIb and fit to the data of Erickson *et al*. (1977).

FIGURE CAPTION

Figure 1 -- Far-infrared maps of Sagittarius B2. The contour levels are 0.1(dashed), 0.2, 0.4, 0.6, and 0.8 of the maximum value (given in Table 1). Beam sizes and wavelengths of the observations are presented in each figure. The two filled circles are the center positions of the two brightest radio continuum sources: #4 to the north and #5 to the south (Martin and Downes 1972; Balick and Sanders 1974).



FWHM 1'.9
λ=220μm
FWHM 55"
λ=166μm
FWHM 55"
λ=125μm
FWHM 30"
λ=60μm
(a)
(b)
(c)
(d)
-28°18'
19'
20'
21'
22'
23'
-28°20'
20s
15s
17h44m10s
5s
0s
α (1950)
δ (1950)

Fig. 1

ADDRESSES

D. A. Harper

Yerkes Observatory

Williams Bay, WI 53191

H. A. Thronson, Jr.

Department of Physics and Astronomy

Box 3905, University Station

University of Wyoming

Laramie, Wyoming 82071

1 Report No NASA TM-88185	2 Government Accession No	3 Recipient's Catalog No

4 Title and Subtitle
FAR-INFRARED OBSERVATIONS OF SAGITTARIUS B2: RECONSIDERATION OF SOURCE STRUCTURE

5 Report Date
October 1985

6. Performing Organization Code

7 Author(s)
Harley A. Thronson, Jr.* and D. A. Harper†

8 Performing Organization Report No
86009

9 Performing Organization Name and Address
*Wyoming Infrared Observatory, University of Wyoming, Laramie, WY 82071
†Yerkes Observatory, University of Chicago, Williams Bay, WI 53191

10 Work Unit No

11 Contract or Grant No

12 Sponsoring Agency Name and Address
National Aeronautics and Space Administration
Washington, DC 20546

13 Type of Report and Period Covered
Technical Memorandum

14 Sponsoring Agency Code
352-02-03

15 Supplementary Notes
Preprint Series #39. Supported by NASA grants.
Point of Contact: L. C. Haughney, Ames Research Center, MS 211-12,
Moffett Field, CA 94035, (415) 694-5339 or FTS 464-5339

16 Abstract
New moderate-angular-resolution far-infrared observations of the Sagittarius B2 star-forming region are presented, discussed, and compared with recent radio molecular and continuum observations of this source. In contrast to previous analyses, we interpret its far-infrared spectrum as the result of a massive frigid cloud overlying a more-or-less normal infrared source, a natural explanation for the object's previously-noted pecularities. The characteristics derived for the obscuring cloud are similar to those found for the W51 MAIN object. Both sources have high sub-millimeter surface brightness, a high ratio of sub-millimeter to far-infrared flux, and numerous regions of molecular maser emission.

17 Key Words (Suggested by Author(s))
Infrared: general
sources
spectra
Nebulae: individual

18 Distribution Statement
Unlimited

Subject category - 89

19 Security Classif (of this report)	20 Security Classif (of this page)	21 No of Pages	22 Price*
Unclassified	Unclassified	23	A03

*For sale by the National Technical Information Service, Springfield, Virginia 22161

End of Document