THE ASTROPHYSICAL JOURNAL, 199:L181–L183, 1975 August 1

SPECTROPHOTOMETRY OF CRL 2688 FROM 2 TO 24 MICRONS

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Received 1975 March 20

ABSTRACT

Medium-resolution spectrophotometry ($\Delta\lambda/\lambda \approx 0.01$) of CRL 2688 from 2 μ to 24 μ are reported. No significant features are found from 3 μ to 24 μ, although the spectral flux distribution is broader than that of a single-temperature blackbody.

Subject headings: infrared sources — nebulae — spectrophotometry

I. INTRODUCTION

This *Letter* reports infrared spectrophotometric observations of the infrared source in Cygnus associated with twin symmetric reflection nebulae which has been recently catalogued by the Air Force Cambridge Research Laboratories Rocket Survey (Walker and Price 1974), where it will be designated as CRL 2688. (Following the convention of using 1950.0 right ascension and declination as a source designation, often used in radio astronomy, one might refer to this source as IR 2100+36.) Spectrophotometry from 2 to 24 μ ($\Delta\lambda/\lambda \sim 0.015$) was obtained at the UCSD–University of Minnesota 152-cm Mount Lemmon infrared telescope between 1974 May 3 and December 27. Table 1 gives a journal of these observations. See Ney *et al.* (1975) and Crampton, Cowley, and Humphreys (1975) for complementary observations and discussions.

II. OBSERVATIONS

The 2–4 μ and 8–13 μ data were obtained using techniques and systems described elsewhere (Merrill, Soifer, and Russell 1975; Gillett and Forrest 1973). The 16–24 μ data were obtained using a newly developed liquid-helium-cooled grating spectrometer, built at UCSD, and which will be more fully described in another publication (Forrest and Soifer 1975). The 2–4 μ observations used α Lyr and α Cyg as calibration standards, and the 8–13 μ observations used α Tau and β Peg as standards. The 16–24 μ observations used the Moon as the spectral calibration, while the absolute level was taken from the 18-μ broad-band data of Ney *et al.* (1975).

TABLE 1

OBSERVING LOG

Date (1974)	Wavelength Region (μ)	Observers
May 3	8–13	KMM
May 20	8–13	BTS & RWR
October 20	2–4	KMM
October 25	2–4	KMM & RWR
November 1	8–13	BTS & RWR
November 4	2–4	KMM
November 5	2–4	EPN & KMM
November 27	8–13	BTS & RWR
December 25	16–24	WJF
December 28	16–24	WJF

The 2–4 μ observations were taken with a 9″ aperture centered on the 3.5-μ flux peak (centered between the optical sources but not completely containing them) to minimize the contribution to the flux from the reflection nebulae. Beam size effects were noted at 1.65, 2.3, and 3.5 μ between concentric 9″ and 18″ beams. No beam size effects were seen at 8–13 μ, and data using apertures between 9″ and 22″ were combined. The 16–24 μ data were taken with an 18″ aperture.

III. DISCUSSION

The spectrum (Fig. 1) shows several qualitative characteristics of note. The entire 3–24 μ spectrum is generally a featureless continuum at this spectral resolution. Although the 16–24 μ data can be fitted by a 120 K blackbody, it is clear that the overall spectrum is too broad to be fit by a single blackbody. The 8–13 μ data suggest a 200 K equivalent blackbody which is hotter than the 10–20 μ color temperature of ~150 K (Ney *et al.* 1975). If, as suggested by Ney *et al.*, the intense infrared flux from this source is due to thermal radiation by warm dust grains, the observed broad flux distribution probably suggests that a range of dust temperatures is being observed. This could be due to the radiation transfer process through an extended dusty envelope and/or geometrical effects in an asymmetric source allowing us to see some warmer dust (e.g., a slightly tilted torus in the model of Ney *et al.*).

The 8–13 μ spectrum of CRL 2688 appears completely smooth and featureless. This lack of features is quite unusual: most objects where the infrared radiation is attributed to thermal reradiation of dust do show features characteristic of the emitting material in this wavelength interval (see Forrest, Gillett, and Stein 1975, and references therein). Thus the overall grain emissivity (due to chemical composition, particle size, etc.), combined with the large optical depth local to the source (inferred from the good agreement between color temperature and surface brightness at 10 μ—Ney *et al.* 1975) must mask these characteristic signatures.

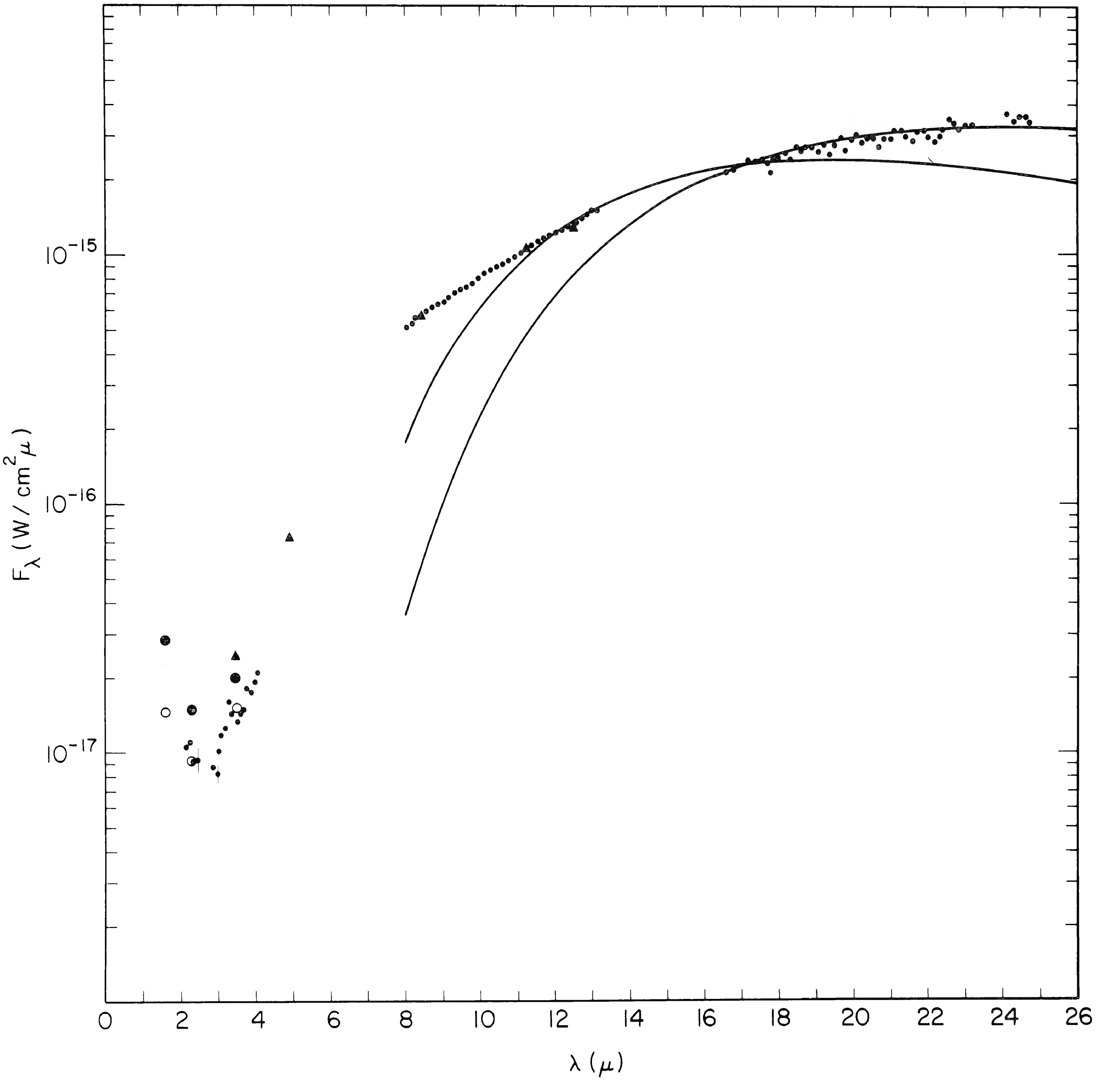

FIG. 1.—The spectrum of CRL 2688 from 2 to 24 μ. *Small filled circles*, narrow-band observations. *Open circles*, *large filled circles*, and *triangles*, broad-band data taken with 9″, 18″, and 22″ apertures. Typical statistical errors in the 2–2.4 μ and 3–4 μ data are shown in the figure. The errors from 8 to 13 μ are typically less than 5%, while the scatter in the measured points is indicative of the errors from 16 to 24 μ. Blackbody curves for 150 K and 120 K (the solid line which is higher at 26 μ) are shown.

Also the absence of any absorption centered near 9.7 μ indicates that there is not a substantial amount of cooler ($T \lesssim 100$ K) silicate dust in the line of sight to this source.

The 2–4 μ region of the spectrum contains the only evidence of structure. The rise toward shorter wavelengths is almost certainly due to the rapidly increasing contribution of reflected light from the obscured central source, as suggested by the marked aperture dependence between concentric 9″ and 18″ apertures (see Fig. 1) as more of the optical sources are contained within the beam (see Ney *et al.* 1975). The 22″ observations, taken on 1974 May 3, were obtained under totally different circumstances from the later 9″ and 18″ observations, and the disagreement between 18″ and 22″ may not be real.

There is no evidence for ice absorption near 3.1 μ, which is not surprising, since at the observed 150 K brightness temperature of the source, the evaporative lifetime of ice is very short. The lack of ice absorption indicates that there is not a significant amount of cold ice ($T \ll 100$ K) in the line of sight to the source, consistent with the lack of observed silicate absorption. A possible emission feature near 3.3 μ is suggested by the data, but this requires further observations for confirmation.

We would like to thank E. P. Ney for calling our attention to this source and for assistance in obtaining some of the data, and W. A. Stein for helpful discussions. Infrared astronomy at UCSD is supported in part by the National Science Foundation and by NASA through grant NGL 05-009-230.

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