A LUMINOUS 3 KILOPARSEC INFRARED DISK IN NGC 1068
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ABSTRACT

We present a 10 μm map of the Seyfert galaxy NGC 1068 and airborne measurements of its angular extent in the far-infrared. We show that the infrared emission originates primarily from two physically distinct regions; approximately half of the total infrared luminosity of 3 × 10^{11} L☉ is associated with the Seyfert nucleus and half with a 3 kpc (35″) diameter disk surrounding it. We argue that the disk component of infrared emission originates from an extended but heavily obscured burst of star formation which resembles those seen in some non-Seyfert galaxies. This high-luminosity disk is distinguished more by its large size than by its high surface brightness. We cannot conclude on the basis of current evidence that the high disk luminosity in NGC 1068 is causally related to its Seyfert activity.

Subject headings: galaxies: individual — galaxies: nuclei — galaxies: Seyfert — infrared: sources — stars: formation

I. INTRODUCTION

NGC 1068 is one of the most luminous galaxies at infrared wavelengths; it emits at least 3 × 10^{11} L☉ in the wavelength range from 1 to 300 μm (Telesto, Harper, and Loewenstein 1976; Telesto, Becklin, and Wynn-Williams 1980). Multi-aperture photometry by Telesto, Becklin, and Wynn-Williams (1980, hereafter TBW) showed that approximately 20% of the 20 μm flux density originates in an extended region greater than 6′′ in diameter (530 pc at 18.1 Mpc, Sandage and Tammann 1975). The remaining power originates at the Seyfert nucleus in a region which is approximately 1′′ in diameter at 10 μm (Becklin et al. 1973).

We present here a 10 μm map and far-infrared scans of the central region surrounding the nucleus of NGC 1068. These data permit for the first time a comparison of the large-scale spatial distributions of infrared, visual, molecular, and radio emission in NGC 1068 and provide a firm basis for the separation of the energy distributions of the nuclear and extended components. We show that the 10 and 60 μm emission originates from a distinct, visually bright region approximately 3 kpc in diameter, and we consider how these observations constrain models for the origin of the large luminosity.

II. OBSERVATIONS AND RESULTS

a) 10 μm Mapping

We mapped the distribution of 10 μm emission from the central 40″ of NGC 1068 on 1980 November 4 with the 3 m telescope of the Infrared Telescope Facility2 (IRTF) at Mauna Kea, Hawaii. The IRTF bolometer was used with a broadband 10 μm filter (central wavelength 10.1 μm, passband 5.1 μm).

The primary flux standard was α Tau, for which we assumed a flux density of 550 Jy at 10.1 μm and 170 Jy at 20 μm. The star α Cet, which is only 6° away from NGC 1068, was used as a local standard. The half-power beam diameter was 5′1″, and the separation between the signal and reference positions was 30° in declination. We observed 38 extranuclear positions, each with an integration time of 400 seconds.

Because of extended wings on the 10 μm beam profile, some flux from the strong 1′′ diameter nuclear source was detected at positions away from the nucleus. Correction for this flux was accomplished by observing the stars α Tau and α Cet at relative positions identical to the displacements from the nucleus at which NGC 1068 was observed. The contribution from the nuclear source to the flux at each point was then determined by normalization of this stellar profile to the nuclear flux level. This flux was then subtracted from the measured fluxes at each position. The correction procedure was very uncertain for positions within 6′′ of the bright nucleus, and therefore these data are not presented. At all other positions the extended emission from the disk of the galaxy was clearly discernible above the nuclear contribution. This is illustrated in Figure 1 by the comparison of a normalized profile of α Cet to the observed profile of NGC 1068 at a position angle of 45°, approximately parallel to the major axis. At the four diagonal positions located 9° from the nucleus the nuclear contribution was approximately half of the total observed flux. For all other positions this contribution was less than 20%. Because of the stable tracking of the IRTF we feel that the corrections for the nuclear source are well determined and do not add significant uncertainty to the resultant fluxes.

In Table 1 and Figures 2 and 3 we present the flux densities corrected for the nuclear contributions; also shown in Figure 3 is an unpublished U band photograph by A. N. Stockton to the same scale as the 10 μm map. All error bars shown in Figures 1 and 2 represent ±σ_m, one standard deviation of the measured mean value, and do not include

1 Also Space Science Division, NASA Ames Research Center.
2 The Infrared Telescope Facility is operated by the University of Hawaii under contract with the National Aeronautics and Space Administration.
systematic errors or uncertainties associated with calibration or the correction for the nuclear contribution. The calibration error is estimated to be $\pm 10\%$ at 10 $\mu$m. The average value of $\sigma_\lambda$ for all points except the nucleus was 26 mJy; thus, the separation between each interval of flux density represented in Figure 3 is $2\sigma_\lambda$. The positional accuracy of the map is $\pm 1''$.

Figure 3 shows that the extended 10 $\mu$m emission originates in a region approximately 35'' (3 kpc) in diameter that is extended along the major axis of the galaxy. Throughout this paper we will refer to this region as a disk, although we note that there are real surface brightness fluctuations in this region and that we cannot determine what the surface brightness is in the central $\pm 7''$ compared to that at larger radii. The integrated flux density of the disk is $2.4 \pm 0.5$ Jy, compared to the measured flux from the nucleus of $21 \pm 1$ Jy. The extended infrared disk therefore contributes only $10\%$ of the total flux density of NGC 1068 at 10 $\mu$m.

The 10 $\mu$m data were supplemented with limited 20 $\mu$m photometry ($\Delta\lambda = 9$ $\mu$m). Using a 3:6 diameter beam, we measured a flux density of $555 \pm 150$ mJy at a position 12'' west and 8'' south of the nucleus, or approximately 2'' south of the brightest 10 $\mu$m point. We measured a nuclear flux density at 20 $\mu$m of $63 \pm 3$ Jy, which agrees with that measured by TBW.

In Figure 4 we have plotted as open circles our value of the flux density of the 3 kpc disk at 10 $\mu$m and an estimate of the 20 $\mu$m flux density from the same region. The plotted 20 $\mu$m flux density is 1.3 times larger than that measured by TBW in a 25'' beam. This factor corrects for 20 $\mu$m emission in the 3 kpc disk outside the 25''. Also plotted in Figure 4 as open squares are the nuclear flux densities at 10 and 20 $\mu$m (TBW) measured through comparably sized apertures ($5''-6''$).

### Far-Infrared Observations

New far-infrared ($\lambda > 30$ $\mu$m) observations of NGC 1068 include scans of the galaxy at 60 and 158 $\mu$m and multi-aperture photometry. The far-infrared photometric observations are summarized in Table 2. We have included all
Fig. 3.—Gray scale map of NGC 1068 (bottom panel) showing the distribution of 10 μm flux density observed with a 5''1 circular beam, compared with U band photograph by A. N. Stockton. Highly uncertain fluxes near the nucleus (cross) are not presented. The separation between each flux interval approximately equals twice the statistical uncertainty in the measured fluxes.
measurements made with University of Chicago photometers on the Kuiper Airborne Observatory (KAO) since the observations reported by Telesco and Harper (1980). The 400 μm measurements were made in collaboration with R. H. Hildebrand and D. T. Jaffe with the IRTF. In Figure 4 we show data taken with beam sizes of 30°–50°. All statistical uncertainties are less than 10%. The water vapor radiometers used to monitor the amount of precipitable water above the KAO were not working on any of the flights on which we observed NGC 1068, so systematic errors may be higher. However, relative values of flux densities measured at different wavelengths but on the same night should be accurate; the shape of the spectrum should be well determined. Data at 40 and 60 μm are in excellent agreement with the earlier results presented by Telesco and Harper (1980). The solid curve in Figure 4 has been drawn through the data of 1980 January, which were taken with a 49° aperture and which span the entire wavelength range of 40–160 μm. Flux densities at λ > 90 μm are somewhat lower than reported by Telesco and Harper (1980) and should be more accurate due to improvements in long-wavelength filters. Accounting for statistical, systematic, and absolute calibration uncertainties, we estimate that the curve in Figure 4 should be accurate to ±30% at 40 < λ < 400 μm.

The multi-aperture measurements made with filters H1–1 and H1–3 in 1981 September provide particularly useful information on the extent of the far-infrared source. The data were taken with a relatively narrow bandpass filter and calibrated directly to Mars, which is essentially a point source for these beam sizes. The increase in flux density with diaphragm diameter demonstrates that a portion of the far-infrared luminosity of NGC 1068 emanates from a region larger than 30° in diameter. The 400 μm flux density of 15 Jy into a 48” beam is about half of that found by Hildebrand et al. (1977) with larger beams, but the statistical significance of the earlier data is not sufficient to draw firm conclusions concerning the size of the source at 400 μm.

The spatial scans of NGC 1068, Mars, and Callisto displayed in Figure 5 were taken with the Yerkes G1 photometer using a 16” x 55” slit and a 45–75 μm bandpass filter (filter G1–2). The horizontal error bars represent conservative estimates of possible systematic errors in guiding. Data points were obtained by beam-switching for several minutes at each position. The peak positions were measured before and after each scan to check for changes in system sensitivity or atmospheric transmission; no significant changes occurred during either the NGC 1068 or calibration scans. Sky-reference beams were separated from the signal beam by 63”; the long axis of the slit was aligned with the line through the signal and reference beams so that any beam smearing due to chopper overshoot lay along the long axis of the slit. We scanned through the galaxy along a line parallel to the major axis of its optically bright central disk and perpendicular to the long axis of the slit.

The scans have been normalized with respect to their peaks and folded by averaging signals from symmetrically displaced offset positions. In no case did the averaged data points differ by more than their statistical errors. Simple modeling of the data shows that the profiles can be well fitted by an elliptical “pillbox” source with major and minor axes of 28” and 18”. The scans shown in Figure 6 were made with the H1 photometer using a 42” aperture and a long-wavelength-pass filter with a half-power point of 130 μm (filter H1–4). For the spectrum of NGC 1068, this results in a flux-weighted spectral width of 120–160 μm (at half-power) and a flux-weighted effective wavelength of 158 μm. For Mars, the calibration source, the corresponding numbers are 118–180 μm and 154 μm, respectively. Hence, the effects of diffraction on beam size should be similar for the two. The sky-reference beams were separated from the signal beam by 45, and the rotation angle (the angle between local vertical and north,
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*a Systems D1 and D2 are described in Moseley 1980. Systems G2 and H1 are described in Harper et al. 1984. System S1 is described by Whitcomb, Hildebrand, and Keene 1980.
*b Angular diameter of circular focal plane aperture projected on the sky.
*c Mean wavelength weighted by source spectrum, filter passband, atmospheric transmission, and diffraction at the focal plane aperture.
*d Flux density at λ_c. For a discussion of the reduction of raw signal ratios to flux densities, see Loewenstein et al. 1977. Statistical errors are all ~0.5%.
*e Spacing between signal and sky reference beams. The two beams were always aligned along a line of constant elevation.
*f The fundamental flux calibration is based on Pioneer spacecraft observations and a thermal model for Mars (see Loewenstein et al. 1977 and Wright 1976). The spectrum of NGC 7027 has been determined from direct comparisons to Mars.

measured clockwise from vertical) varied from 354° to 775° during the observations. Data were taken at points displaced from the nucleus by 24° in elevation and azimuth and by 22° and 44° along a line 45° from vertical and approximately parallel to the optical major axis of the galaxy.

In addition to the data points for NGC 1068, we have plotted best-fit Gaussian curves and beam profiles in elevation and azimuth determined from scans of Mars. We have assumed that the beam profile for the major-axis scan can be represented by the mean of the horizontal and vertical beam profiles. A Gaussian deconvolution of the source and beam scans yields half-power source widths of 60°, 44°, and 32° for the major axis, azimuth, and elevation, respectively. These numbers are consistent with an elliptical source having an orientation and axial ratio (~0.6) similar to those of the optical emission.

III. DISCUSSION

a) Two Distinct Infrared Components

We have shown that NGC 1068 emits infrared radiation on a scale of 3 kpc at 10 and 60 μm. This extended component dominates the far-infrared emission, but at the shorter infrared wavelengths it is considerably weaker than the nucleus. The contrast between the nucleus and its surroundings is also significantly higher near 10 μm than in the visible; the ratio of integrated fluxes from the nucleus and disk is approximately 0.5 at visible wavelengths (Smith, Weedman, and Spinrad

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1972) compared to approximately 10 at 10 \( \mu m \). From the plot of the energy distribution in Figure 4 it is evident that the 10 and 20 \( \mu m \) points for the infrared disk lie on a plausible extrapolation of the energy distribution computed from measurements at \( \lambda > 30 \mu m \) and that this extended emission is distinct from the nuclear emission which dominates at \( \lambda < 30 \mu m \). We therefore believe that the 3 kpc 10 \( \mu m \) disk is identical to the dominant far-infrared source and that a consistent picture emerges of a large, relatively cool infrared disk surrounding a hotter nucleus. This combination of extended emission which peaks at \( \sim 100 \mu m \) and nuclear emission peaking near 20 \( \mu m \) leads to the complex shape of NGC 1068's overall energy distribution. The distinction between the "warm" nuclear and the "cool" extended sources is also demonstrated by the 10-20 \( \mu m \) color temperatures of the two regions; the ratio of the 20 and 10 \( \mu m \) flux densities for the extended component is 10 \( \pm 3 \) from the data in Figure 4, and 7 \( \pm 2 \) from the 20 \( \mu m \) measurement with a 3'6 aperture. The value of that ratio for the nucleus is 3.2 \( \pm 0.5 \).

The total flux longward of 10 \( \mu m \) in the extended disk obtained by integration under the long-dashed curve in Figure 4 is \( 1.9 \times 10^{-8} \) ergs cm\(^{-2}\) s\(^{-1}\). At 18.1 Mpc this corresponds to a luminosity of \( 1.8 \times 10^{11} L_\odot \), with an uncertainty of \( \pm 40\% \). The infrared luminosity of the nuclear core source, as determined by integration under the short-dashed curve, is \( 1.4 \times 10^{11} L_\odot \), with an uncertainty of \( \pm 15\% \). Thus, the bolometric luminosities of the hotter nuclear source and of the cooler 3 kpc region are comparable. From the multi-aperture far-infrared photometry and the 158 \( \mu m \) scans, we estimate that the flux longward of 60 \( \mu m \) from radii greater than 15' is \( \sim 2 \times 10^{10} L_\odot \).

b) Comparison with Visible, Molecular, and Radio Continuum Emission

As is evident from Figure 3, NGC 1068 possesses a visually bright region which is several kiloparsecs in size (see also Sandage 1961). Keel and Weedman (1978) noted that this region has the highest surface brightness of any known galaxian disk. Comparison of the 10 \( \mu m \) map and the \( U \) photograph shows that NGC 1068 emits strong 10 \( \mu m \) radiation across this region of prominent visual emission. Although our map does not extend in all directions to positions of zero 10 \( \mu m \) flux, there are sufficient data, especially the scan along the major axis (Figs. 2 and 3), to suggest that the extended infrared emission is generally coextensive with the visually bright disk. However, the overall spatial correlation between visible and infrared emission does not apply in detail; a particularly notable exception to the correlation is the region of strongest 10 \( \mu m \) emission, located 6' south and 12' west of the nucleus, which is relatively faint visually.

Strong 2.6 mm CO emission was detected from NGC 1068 by Rickard et al. (1977). The spatial distribution of this molecular material has been studied by Scoville, Young, and Lucy (1983) using a mapping technique based on the comparison of low spatial resolution CO profiles with kinematic data obtained from visible emission lines. They deduce that the bulk of the molecular line emission comes from a ring of clouds about 2.4 kpc (27') in diameter, with a radial thickness of about 0.3 kpc. The similarity between the model CO distribution and the observed 10 \( \mu m \) distribution is striking, and, given the observational and modeling uncertainties, it is plausible that the extended infrared and molecular emission beyond 5' originates in the same region. However, the scans and multi-aperture data at \( \lambda > 130 \mu m \) suggest that there may be a significant amount of dust (and, by inference, gas) at radii greater than 15'. The temperatures and excitation conditions in these clouds may be very different from those in the 30' diameter disk. A full analysis of the distributions of interstellar matter and the mass-to-luminosity ratio within the galactic disk as a whole must await more detailed observations.

The radio continuum emission from NGC 1068 has been studied at high spatial resolution by Wilson and Ulvestad (1982). They showed that the central \( \pm 8' \) of the galaxy is dominated by a nuclear source plus a pair of "jets" that extend approximately along the major axis of the galaxy. Unfortunately, these jets lie within the region where confusion from the strong nucleus precludes mapping at 10 \( \mu m \) (Fig. 3 and § 4.1o). In order to look for radio continuum emission (particularly free-free emission) associated with the larger 10 \( \mu m \) emitting region, we have used the VLA to make lower resolution (6'5 HPBW) maps of NGC 1068 at 2.6, and 20 cm that extend to \( \pm 60' \) from the center of the galaxy (Wynn-Williams, Scoville, and Becklin, in preparation). Preliminary analysis of these data indicates the presence of a significant shoulder of nonthermal emission at a distance of about 8' from the nucleus, but no clear evidence for thermal emission above an average level of 2 mJy in a 6.5' beam from the region of the 10 \( \mu m \) disk.

c) Nature of Heating Sources for the Extended Emission

TBW considered whether the dust in the infrared disk of NGC 1068 could be radiatively heated by a compact source of luminosity located at the nucleus. By considering the equilibrium temperature of a grain exposed to the radiation at a distance of 260 pc from the nucleus, they showed that the high color temperature of the grains (>73 K) cannot be maintained except under the rather artificial assumptions that the grains have an exceptionally rapid emissivity decrease with wavelength or that the nucleus emits most of its radiation in the ultraviolet rather than at 5-20 \( \mu m \), as observed. Our new observations provide even stronger evidence for heating sources that are distributed throughout the extended disk. In particular, our 10 \( \mu m \) mapping shows that the grains are both considerably hotter (~160 K) and much farther away from the nucleus (~1.5 kpc) than assumed by TBW. Furthermore, the large amount of dust in the disk as determined from 350 \( \mu m \) observations by Hildebrand et al. (1977), corroborated by the data at \( \lambda > 130 \mu m \) presented here and the CO observations and analysis by Scoville, Young, and Lucy (1983), indicate a mean free path to ultraviolet radiation in the plane of less than 10 pc. We conclude that sources of luminosity distributed similarly to the 10 and 60 \( \mu m \) emission heat the grains in the extended region.

We can gain insight into the nature of the distributed heating sources by comparing the infrared luminosity observed at \( \lambda > 10 \mu m \) to the direct stellar radiation emerging at other wavelengths. In doing so it is important to exclude from consideration radiation from the Seyfert nucleus. Photometry at 2 \( \mu m \) with 5' and 30' beams (Penston et al. 1974) and 7' and 34' UVB photometry (Smith, Weedman, and Spinrad 1972) imply that \( 2.3 \times 10^{10} L_\odot \) is observed at 0.4 to 2.2 \( \mu m \) from the disk which emits the 10 \( \mu m \) radiation. Large beam ultraviolet observations (Code and Welch 1982) indicate that less than \( 5 \times 10^9 L_\odot \) is emitted in the range 0.15-0.4 \( \mu m \).
can set a generous upper limit of $1.3 \times 10^{10} L_\odot$ for light from very blue stars emitting at $\lambda < 0.15 \mu m$ by assuming that all of the 24 mJy observed at 0.15 $\mu m$ (Code and Welch 1982) originates in 50,000 K blackbodies. We conclude that the direct stellar ultraviolet, visible, and near-infrared radiation, corresponding to less than $4 \times 10^{10} L_\odot$, is less than 20% of the observed power from the 3 kpc disk in NGC 1068. The fact that the visible disk of NGC 1068 is significantly bluer than expected for its morphological type (Smith, Weedman, and Spinrad 1972) implies that the luminosity of the visible population has not been underestimated as a result of normal interstellar reddening. Rather, most of the power emerging from the disk originates in sources which are hidden from view.

The spatial correlation of the infrared flux with the blue, clumpy disk rich both in emission lines from H II regions and in photospheric absorption features from hot stars (Balick and Heckman 1979; Beck, Beckwith, and Gatley 1983) implies that the infrared radiation originates in dust heated by a burst of star formation. This conclusion is strongly supported by the association with molecular clouds and by an energy distribution resembling those of Galactic H II region/molecular cloud complexes powered by massive stars (see, e.g., Thronson and Harper 1979). The agreement in general but not in detail between the visible emission and the 10 $\mu m$ emission in the disk of NGC 1068 is naturally explained by this model. In particular, we might expect the youngest and most luminous stars to be associated with especially strong concentrations of dust and gas, readily explaining the association of the strongest 10 $\mu m$ with the visually dark lane.

d) Comparison with Other Galaxies

Ten micron emission extended on a scale of kiloparsecs has been observed in several other galaxies which do not contain bright Seyfert nuclei and for which the orientation of the galaxian planes permits a comparison of the infrared and visual distributions. Most of the 10 $\mu m$ radiation from NGC 1097 (average 10 $\mu m$ intensity = 3.6 mJy arcsec$^{-2}$) originates in a visually bright ring 2 kpc in diameter (Telesco and Gatley 1981), the light of which is dominated by that from an early stellar population (Talent 1982). The galaxies M51 (0.6 mJy arcsec$^{-2}$; Telesco and Gatley, in preparation) and NGC 3310 (1.7 mJy arcsec$^{-2}$; Telesco and Gatley 1984) exhibit a similar large-scale correlation, with emission line data for both galaxies indicating abundant young stars in the extended 10 $\mu m$ regions. The surface brightness of the disk in NGC 1068 is 4.1 mJy arcsec$^{-2}$, which is comparable to the brightness in those non-Seyfert—but not necessarily non-active—galaxies. Although much smaller than the infrared disk in NGC 1068, the central 230 pc of the Milky Way emits strong infrared radiation associated with H II region/molecular cloud complexes (Gatley and Becklin 1981). If the elliptically shaped 10 $\mu m$ emitting region (Daehler and Price 1982) is interpreted as an edge-on disk that is 230 pc in diameter centered on the nucleus, the average face-on surface brightness of the Galactic Center is 2.2 mJy arcsec$^{-2}$. The brightness of NGC 1068's disk is comparable to that of the central "disk" of the Milky Way despite a difference of several orders of magnitude in total power output.

Extending our comparison to longer wavelengths, we find that the central 500 pc of M82, which is experiencing a powerful burst of star formation (Telesco and Harper 1980; Rieke et al. 1980), has a 60 $\mu m$ surface brightness that is 6 times greater than that of the disk in NGC 1068. However, the luminosity of NGC 1068's disk is 6 times greater than the center of M82. What appears to distinguish the infrared source in NGC 1068 from those in the Milky Way and these other galaxies is its physical size rather than high surface brightness.

It is also notable that the ratio of the far-infrared flux (as indicated by the 80 $\mu m$ flux density) to the CO line flux for NGC 1068 is comparable to that for the other galaxies in Telesco and Harper's (1980) sample, even though NGC 1068 is by far the most luminous galaxy they considered. Rickard et al. (as quoted by Morris and Rickard 1982) confirmed this relation for a larger sample of galaxies.

Therefore, the observed properties of the extended infrared disk in NGC 1068 do not seem to require that its high luminosity be related to the Seyfert activity. Even if the disk has been significantly perturbed by nuclear activity, as proposed by Wilson and Ulvestad (1982) and others, related star formation may not be clearly distinguishable at infrared wavelengths from star formation initiated in other ways such as by spiral density waves or stochastic processes.

e) The Nuclear Source

The new observations discussed in this paper do not directly address the question of the nature of the compact nuclear source. However, they do imply that the infrared energy distribution of the nucleus is significantly different from that of conventional star-forming regions. Successful models for the nucleus of NGC 1068 must be able to maintain grain temperatures of 200 K—far hotter than the 20–50 K generally found in molecular clouds.

IV. SUMMARY AND CONCLUSIONS

We have mapped the infrared emission external to the Seyfert nucleus in NGC 1068. Our observations indicate the following:

1. The infrared emission from NGC 1068 consists of three components. There is a compact nuclear source which dominates emission at 2–20 $\mu m$, and an extended 3 kpc region that emits most of the luminosity at $\lambda > 30 \mu m$. Each of these has a luminosity of 1–2 x $10^{11} L_\odot$. A considerably smaller flux emerges at $\lambda > 100 \mu m$ at radii beyond 15’.

2. The extended 3 kpc region coincides with a visually bright region that contains a massive ring of molecular clouds.

3. The luminosity of the infrared disk cannot originate from reradiation of power originally emitted from the nucleus. It is most probably produced by an extended burst of star formation in the disk. Since the near-infrared, visible, and ultraviolet luminosity of the disk is much less than the infrared luminosity of the same region, most of this star-forming activity must occur in heavily obscured regions.

4. The surface brightness and energy distribution of the extended infrared radiation of NGC 1068 resembles that observed in the central regions of some non-Seyfert galaxies. It is its large physical size rather than its high surface brightness that distinguishes the infrared source in NGC 1068 from those in other galaxies. The observed properties of the disk do not seem to require that its high luminosity be related to the Seyfert activity.

5. The energy distribution of the infrared source associated with the Seyfert nucleus is very different from that associated with star-forming regions in our own or other galaxies.
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