THE ASTROPHYSICAL JOURNAL, 278:L7–L10, 1984 March 1

THE *IRAS*[1] MINISURVEY

M. ROWAN-ROBINSON, P. E. CLEGG, C. A. BEICHMAN, G. NEUGEBAUER, B. T. SOIFER, H. H. AUMANN, D. A. BEINTEMA, N. BOGGESS, J. P. EMERSON, T. N. GAUTIER, F. C. GILLETT, M. G. HAUSER, J. R. HOUCK, F. J. LOW, AND R. G. WALKER
Received 1983 September 16; accepted 1983 November 21

ABSTRACT

Before the main *IRAS* all-sky survey was started, a preliminary survey of 900 deg^2 was carried out. Some results from this "minisurvey" are given here. The completeness of the minisurvey at galactic latitudes $|b| = 20°–40°$ drops sharply at flux densities below 0.4, 0.4, 0.5, and 2.5 Jy at 12, 25, 60, and 100 μm. The corresponding surface densities of point sources brighter than these flux levels are 1.1, 0.4, 0.65, and 1.25 deg^{-2} respectively. Outside the galactic plane, the majority of the sources at 12 and 25 μm are stars, while galaxies make up a significant proportion of 60 μm sources. The 100 μm band is dominated by emission from interstellar dust over much of the minisurvey area.

Subject headings: infrared: general — infrared: sources

I. INTRODUCTION

The main goal of the *IRAS* mission is an unbiased survey of the sky at infrared wavelengths. Before the survey of the entire sky was started, an initial survey, called the minisurvey, was completed.

The area of the sky chosen for the minisurvey, approximately 900 deg^2, consists of two strips of sky centered approximately on ecliptic longitudes 60° and 252°. The region of the sky was that area available immediately after cover ejection so it was not necessarily optimal for astronomical study, particularly since no part of the sky above galactic latitude 40° was scanned. Part of the minisurvey area was covered with four hours-confirming sets of scans (Neugebauer *et al.* 1984) to provide a basis for testing the processing of the survey.

The *Letter* discusses the minisurvey data and their quality and gives an overview of one portion of the infrared sky.

II. THE MINISURVEY: OBSERVATIONS

A total of 8709 sources in the minisurvey with signal-to-noise ratios greater than 3 in at least one wavelength band satisfied the minimum confirmation requirement for two hours-confirmed observations. The distribution in galactic latitude, b, of these sources is illustrated in Figure 1 for the four *IRAS* bands centered at 12, 25, 60, and 100 μm.

Figure 2 shows source counts based on the minisurvey data for $40° \geq |b| \geq 20°$. The completeness drops sharply at flux densities below 0.4, 0.4, 0.5, and 2.5 Jy at 12, 25, 60, and 100 μm respectively. These correspond approximately to signal-to-noise ratios of 6, 6, 6, and 9, respectively, where the noise refers to the rms noise on a single sample. For $40° \geq |b| \geq 20°$, the total numbers of sources seen in the minisurvey per square degree brighter than these flux levels are 1.1, 0.4, 0.65, and 1.25 respectively.

We estimate that we are confusion limited at 100 μm over much of the minisurvey area. Over much of the galactic plane, we are probably confusion limited in all four bands. A preliminary analysis shows that for signal-to-noise ratios greater

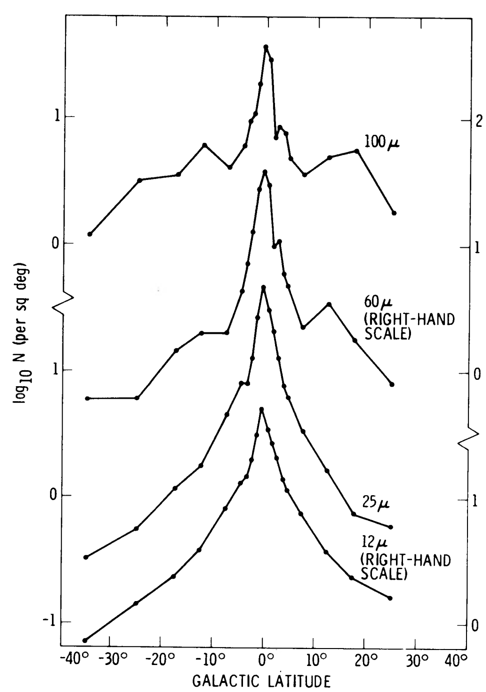

FIG. 1.—The total number of sources per square degree in bins of galactic latitudes for the minisurvey. Each datum point is the average for two strips of the sky, one crossing the galactic plane at a longitude of approximately 338° and the other at approximately 144°. From the bottom, the curves are for the bands centered at 12 μm (lower right-hand scale), 25 μm (lower left-hand scale), 60 μm (upper right-hand scale), and 100 μm (upper left-hand scale).

[1]The *Infrared Astronomical Satellite* was developed and is operated by the Netherlands Agency for Aerospace Programs (NIVR), the US National Aeronautics and Space Administration (NASA), and the UK Science and Engineering Research Council (SERC).

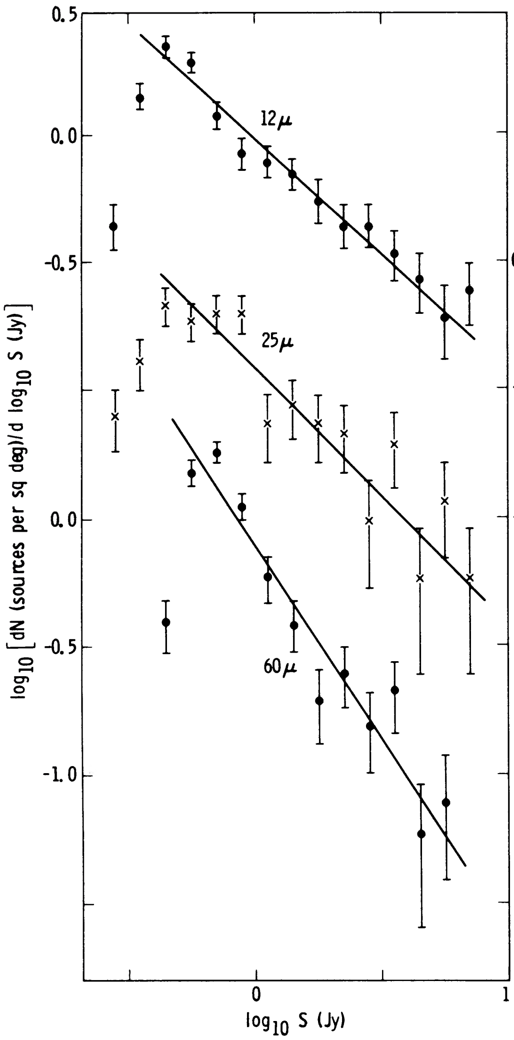

FIG. 2*a*

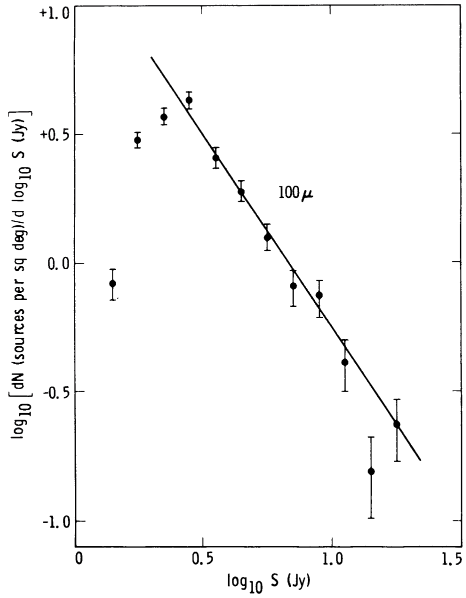

FIG. 2*b*

FIG. 2.—Differential source counts for $40° \geq |b| \geq 20°$. The ordinate is $dN/d\,(\log_{10}S)$, where N is the number of sources per square degree brighter than a flux density S in Jy. The slopes for the power-law fits are -0.9, -1.0, -1.5, and -1.5. The data are preliminary, and the comparison power laws are illustrative only.

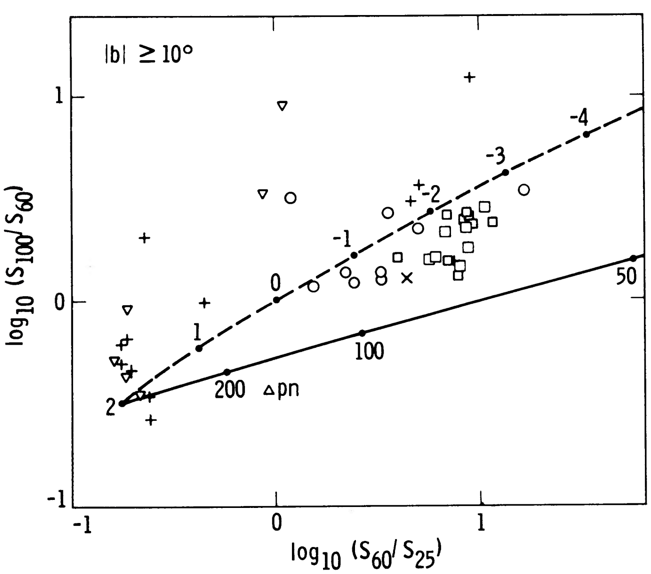

FIG. 3*a*

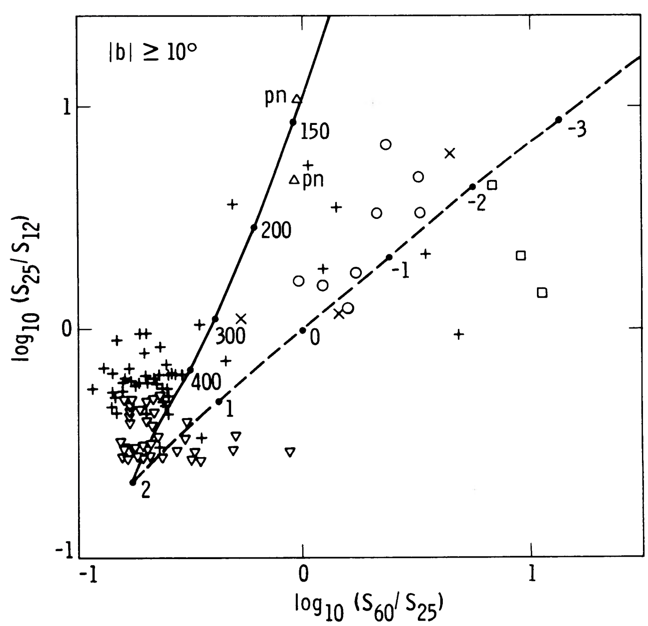

FIG. 3*b*

FIG. 3.—Color-color diagrams for minisurvey sources seen in three or more bands. S_{12}, S_{25}, S_{60} and S_{100} are flux densities in the 12, 25, 60, and 100 μm *IRAS* wavelength bands respectively. *Squares*, galaxies; *inverted triangles*, late-type stars (K, M, C); ×, early-type star; *triangle*, radio sources; pn, planetary nebulae; *circles*, embedded young or pre-main-sequence stars (e.g., B5 IRS 1, GL 490); and +, not yet identified. The solid and broken curves are the loci for blackbody and power-law sources, labeled with the temperature and spectral index ($d\log S/d\log \nu$) respectively.

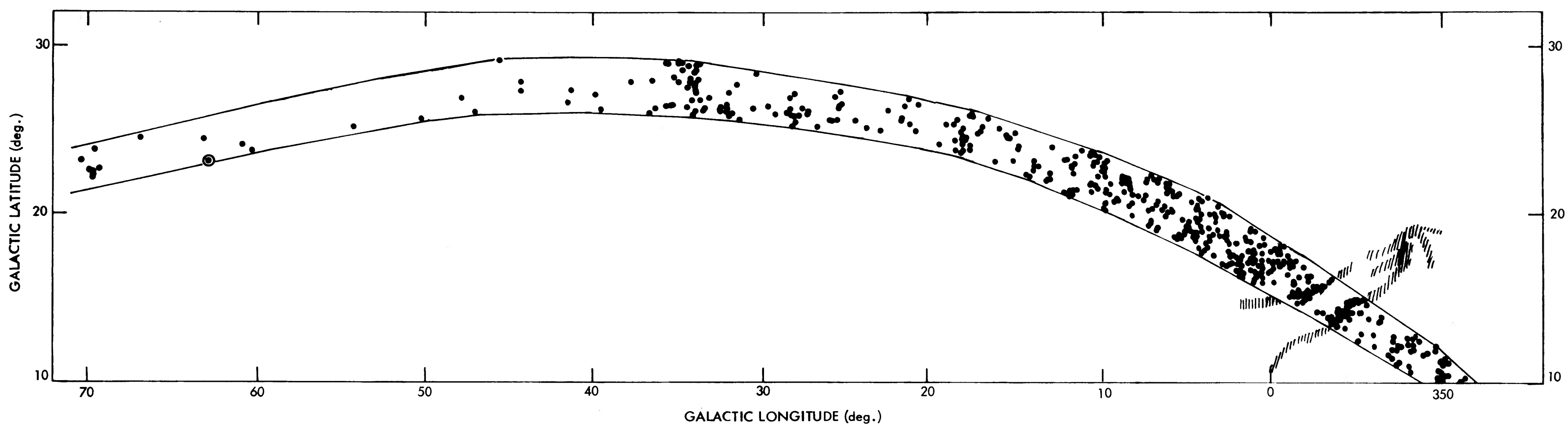

FIG. 4.—The distribution on the sky in galactic coordinates, for a portion of the minisurvey, of the sources seen at 100 μm only. Note the concentrations of the sources into clouds, particularly for $|b| < 20°$. A rough sketch of some of the dark clouds associated with the Ophiuchus dark cloud complex, outside the minisurvey strip, is given. Sources associated with galaxies are shown circled.

than 9, the main survey, consisting of three hours-confirming sets of scans, is highly reliable (> 99.8% at 12 and 60 μm) and reasonably complete (> 95% at 12, 25, and 60 μm) outside confused regions.

For minisurvey sources at $|b| > 10°$ seen in three adjacent bands, we have made color-color diagrams (Figs. 3*a* and 3*b*). Different symbols have been used for sources identified with different classes of astronomical objects, and the loci of blackbody and power-law spectra are shown. These diagrams are discussed below.

III. IDENTIFICATION OF SOURCES IN MINISURVEY AREA

We have compared the confirmed minisurvey sources with a number of standard astronomical catalogs, particularly the SAO Star Catalog (1966) and the *Master List of Nonstellar Optical Astronomical Objects* (Dixon and Sonneborn 1980) requiring a positional agreement of 1′ or better. We give the results of these comparisons below.

1. At $|b| > 20°$, more than half of the 12 and 25 μm sources in the minisurvey can be identified with stars in the SAO catalog. The most common spectral types found are K and M. Many of the rest of these sources are undoubtedly stars fainter than the limit of the SAO catalog.

2. About a quarter of the minisurvey sources with $|b| > 20°$ which are seen both at 60 and 100 μm can be identified with cataloged galaxies. The surface density of 60 μm minisurvey sources brighter than 0.5 Jy identified with galaxies brighter than 18th magnitude is approximately 0.25 galaxies per square degree (Soifer *et al.* 1984). Another 0.07 sources per square degree are identified as stars, many with circumstellar dust shells. Many of the remaining 60 μm sources may be galaxies fainter than 18th magnitude: the surface density of *IRAS* galaxies therefore lies in the range 0.25–0.5 deg^{-2}. The remaining 60 μm sources are composed of: sources with color temperatures ranging from 25 to 150 K found in galactic dust clouds, presumably pre–main-sequence objects, and some unidentified sources (Houck *et al.* 1984).

3. Even at quite high galactic latitudes, many of the sources are seen only at 100 μm, implying color temperatures less than 25 K (see Low *et al.* 1984). The sources with emission at 100 μm only and $|b| > 10°$ show a cloudy or "cirrus-like" distribution (Fig. 4). Some of the clouds of 100 μm only sources also have concentrations of sources seen at 60 and 100 μm (and in some cases other bands). The color temperatures of these sources generally lie in the 25–30 K range. The distribution of these sources is also shown. Some of the clouds of 100 μm only sources can be identified with known dark clouds from the Lynds catalog (Lynds 1962) or H I structures seen by Heiles (1975).

Often, the 100 μm sources do not have a particularly good correlation with the point-source template because the sources are extended or are only bits of structure on the point-source angular scale (~ 4′) within a more extended region of emission. This complex structure typically has signal-to-noise ratios of less than 10 and significantly impacts the completeness and reliability of the point-source survey at 100 μm.

4. Most of the sources within 10° of the galactic plane are unidentified. A few are identified with H II regions, planetary nebulae, and other types of diffuse nebulae, with stars, many of which have strong infrared excesses, and with young massive stars with bipolar outflows (e.g., GL 490). Many have far-infrared spectra consistent with being star-forming regions.

5. Several classes of objects are confined to reasonably well defined regions of the color-color diagrams in Figure 3. A clump of late-type stars (K, M, C) with little or no circumstellar dust are found close to the 2000–3000 K blackbody locus. Two sequences of late-type stars with far-infrared excess are seen in Figure 3*b*. In one, the 25–60 μm color changes much less than the 12–25 μm color. These are stars with substantial circumstellar dust shells. In the other sequence, the 25–60 μm color changes far more than the 12–25 μm color. These are mainly K stars in Figure 3*b*, but some A and B stars in the galactic plane have similar colors. Planetary nebulae, H II regions, galaxies, and embedded young or pre–main-sequence objects all have reasonably well defined far-infrared colors.

We would like to thank all those who have worked to make *IRAS* a success. We particularly wish to thank Tom Chester and the Science Support Team at JPL for their enthusiastic support of this work. Judy Bennett, Perry Hacking, David Walker, and John Fairclough provided programming assistance with parts of this work.

REFERENCES

Dixon, R. S., and Sonneborn, G. I. 1980, *Master List of Nonstellar Optical Astronomical Objects* (Columbus: Ohio State University Press).
Heiles, D. 1975, *Astr. Ap. Suppl.*, **20**, 37.
Houck, J. R., *et al.* 1984, *Ap. J.* (*Letters*), **278**, L63.
Low, F. J., *et al.* 1984, *Ap. J.* (*Letters*), **278**, L19.
Lynds, B. T. 1962, *Ap. J. Suppl.*, **7**, 1.
Neugebauer, G., *et al.* 1984, *Ap. J.* (*Letters*) **278**, L1 (Paper I).
Smithsonian Astrophysical Observatory. 1966, *Star Catalog* (Washington, D.C.: Smithsonian Institution Publication 4652).
Soifer, B. T., *et al.* 1984, *Ap. J.* (*Letters*), **278**, L71.