LARGE-SCALE MAPPING OF THE GALAXY BY IRAS

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ABSTRACT

The Infrared Astronomical Satellite (IRAS), launched 1983 January 25, has been conducting a high-sensitivity, high-resolution all-sky photometric survey at wavelengths of 12, 25, 60, and 100 μm in the infrared. One of the data products from the survey will be a map of the entire Milky Way within latitude limits of 10 degrees at a resolution of 4 arcminutes. Since the IRAS detector system is DC-coupled and has demonstrated excellent stability, this map will contain reliable information on all spatial scales larger than the map resolution. The extremely high sensitivity of the IRAS instrument for the detection of interstellar material in the survey mode is illustrated here in terms of visual extinction and dust and gas column densities.

I. INTRODUCTION

The Infrared Astronomical Satellite (IRAS) has been designed to carry out an all-sky photometric survey in four wavelength bands in the spectral region from 8 to 120 μm. The satellite, developed and operated jointly by the United States (NASA), the Netherlands (NIVR), and England (SERC), contains a 60-cm aperture, liquid-helium cooled telescope and infrared instrumentation. IRAS was successfully launched into a 900-km altitude, near-polar orbit on 1983 January 25. Table 1 summarizes the characteristics of the instrument. In the survey mode, IRAS scans the sky in long tracks extending roughly from ecliptic pole to ecliptic pole at fixed solar offset angle. The survey is being conducted so that each point on the sky is scanned by the entire array a minimum of four times in two pairs of observations. The two observations within a pair are separated by a few hours and the pairs are separated by about one week.

One of the planned data products of the survey is a map along the galactic plane extending to a latitude of 10 degrees on both sides of the plane. To produce this map, the survey data will be binned into 2-arcmin square pixels to match the instrumental cross-scan sampling

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interval. The signals from the IRAS detectors are dc-coupled, and the system has shown excellent dc stability in flight. Hence, the galactic-plane map is expected to be photometrically meaningful on all spatial scales larger than the pixel size. In the remainder of this article we shall address the expected sensitivity in this map for interstellar material, and describe a very small sample of early data. A more extensive description of the IRAS instrumentation and survey method has recently been published by the IRAS Science Working Group (1983). Current plans call for release of the reduced IRAS survey data in the fall of 1984.

II. SENSITIVITY FOR DETECTION OF INTERSTELLAR MATTER

The noise - equivalent flux densities and intensities of typical IRAS detectors in flight are given in Table 1 for a frequency corresponding to spatial scales of a few tens of degrees.

TABLE 1. IRAS Passbands and Noise for a Typical Detector

Band	$\lambda(\mu m)$	$d\lambda/\lambda$	NEFD($Jy\ Hz^{-1/2}$)	NEI_ν($Jy\ sr^{-1}Hz^{-1/2}$)
1	12	0.5	0.075	2.6×10^5
2	25	0.4	0.075	2.6×10^5
3	60	0.5	0.16	2.7×10^5
4	100	0.3	0.80	6.3×10^5

This noise performance has been translated into some predictions of what should be visible in the survey data in terms of astrophysically significant quantities. To express the results in these terms, we have assumed that the following are typical properties for the interstellar dust and gas:

$$\tau_\nu = K_\nu M_D,\ K_\nu = 4.6(\nu/10^{12})^2\ cm^2g^{-1},\ M_H/M_D = 10^2$$

$$N_H/A_V = 2 \times 10^{21}\ cm^{-2}mag^{-1},\ N_H = 3.2 \times 10^{20} \int T_a(^{12}CO)\ dv\ cm^{-2}$$

where M_H = gas mass column density, N_H = gas number column density, M_D = dust mass column density, A_V = visual extinction, K_ν = dust mass absorption coefficient, ν = optical frequency, v = velocity and τ_ν = optical depth. We consider detection of thermal emission from optically thin dust clouds of temperature T. The detectable dust optical depth is obtained directly from the system-noise-equivalent flux for any assumed dust temperature, and the result expressed in terms of column densities or extinction using the above assumptions. Figure 1 shows the 5σ detection levels for the 60- and 100-μm IRAS bands as a function of dust temperature for data smoothed to a 1/2-degree square beam (average of 16 detectors integrated for 8 seconds). For dust warmer than about 15K, IRAS sensiti-

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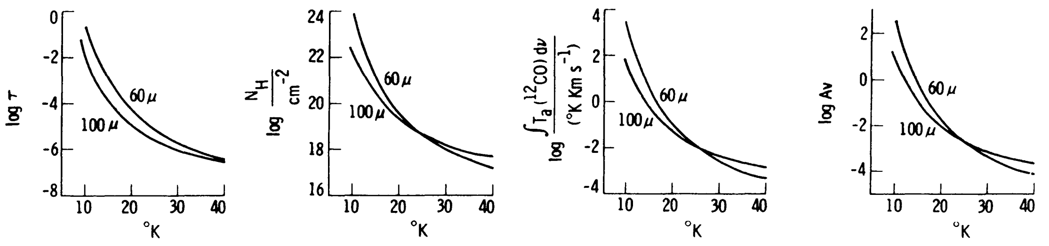

Figure 1. IRAS 5σ detection limits for various astrophysical parameters. Data integrated to 0.5-deg square beam.

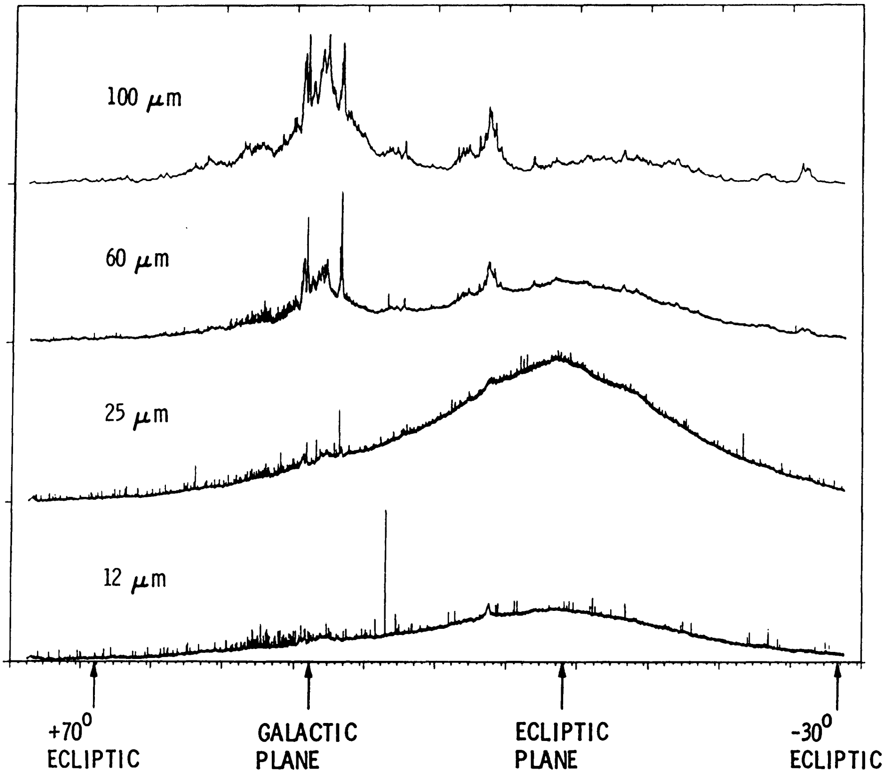

Figure 2. Time history for one detector from each band during one scan. Vertical axes are offset. The abscissa is labelled in ecliptic latitude.

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vity to interstellar material is clearly at least comparable to that attained with other techniques.

III. GALACTIC-PLANE EMISSION

A sample of IRAS survey data is shown in Figure 2. These data are from a scan at about 90^{o} from the Sun which crosses the Milky Way at an angle of 48^{o} near galactic longitude 140^{o}. Except for the section with many spikes near the Galactic plane, obtained when the satellite passed through the northern horn of the Van Allen belt, there is no noise visible in the figure. All features are due to the sky and reproduce to a high degree of accuracy from scan to scan. A notable feature in Figure 2 is the dominant contribution of the interplanetary dust emission at wavelengths shorter than 100 μm.

We shall eventually construct a detailed model of the "zodiacal emission" to permit discrimination between solar-system and galactic emission. Though these results are very fragmentary, it is already clear that the infrared maps of the Galaxy to be obtained by IRAS will be a major new resource for study of the structure and constituents of the Milky Way.

REFERENCE

IRAS Science Working Group 1983, Nature 303, 287.

DISCUSSION

R. Wielen: Could you describe the IRAS results on the Andromeda Nebula?

Gautier: Results on M31 will be discussed by Habing later during the Symposium (Section II.9).

H. Okuda: Do the detection limits achieved on IRAS in actual operation agree with the ultimate sensitivity levels obtained in the laboratory?

Gautier: We do indeed obtain noise levels in 2 arcmin windows consistent with those expected.