A MODEL OF THE 8–25 μm POINT SOURCE INFRARED SKY

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ABSTRACT. We have constructed a detailed model for the infrared (IR) point source sky that comprises geometrically and physically realistic representations of the galactic disk, bulge, stellar halo, spiral arms (including the "local arm"), molecular ring, and the extragalactic sky. We represent each of the distinct galactic components by up to 87 types of galactic source, each fully characterized by scale heights, space densities, and absolute magnitudes at *BVJHK*, 12, and 25 μm, and a spectrum from the *IRAS* Low Resolution Spectrometer (LRS). Our model has been guided by a parallel Monte Carlo simulation of the Galaxy at 12 μm. The content of our galactic source table constitutes an excellent match to the 12 μm luminosity function in the simulation, as well as to the luminosity functions at *V* and *K*. We are able to predict differential and cumulative IR source counts for any bandpass lying fully within the *IRAS* LRS range (7.7–22.7 μm) as well as for the *IRAS* 12 and 25 μm bands. These source counts match the *IRAS* observations extremely well. The model can be used to predict the character of the point source sky expected for observations from future IR space experiments (e.g., *ISO*, *SIRTF*, *LDR*).

1. INTRODUCTION

In 1983, the *IRAS* satellite surveyed the sky at wavelengths of 12, 25, 60, and 100 μm. At 12 and 25 μm, many of the point sources seen by *IRAS* are red giant stars with mass loss; these stars are very luminous in the mid-IR and can therefore be seen at great distances. The extinction at these wavelengths is relatively small, so these stars are seen even at low galactic latitudes. The *IRAS* Point Source Catalog (1988, hereafter PSC) therefore offers a valuable tool for studying the structure of our Galaxy.

We have constructed a model for the Galaxy and for extragalactic sources which predicts the observed source counts for a specified direction. We have attempted to represent the Galaxy with as much physical realism as possible, using Galactic structure information gathered at other wavelengths (particularly at optical wavelengths). The model operates in the *BVJHK* passbands as well as the *IRAS* 12 and 25 μm passbands. We have utilized spectra from the *IRAS* LRS to extend the model to cover any arbitrary passband lying fully within the LRS wavelength range (7.7–22.7 μm).

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2. THE GALAXY

We found it necessary to include five distinct structural components in the Galaxy. These are: (1) disk—we used a disk exponential in both the radial and vertical directions and with a radial truncation; (2) bulge—this was assumed to have a form similar to that proposed by Bahcall (1986), and to contain an old population of stars; (3) stellar halo—this was assumed to have the form of a de Vaucouleurs law and to contain old, metal-poor stars; (4) spiral arms—a four arm logarithmic spiral pattern was used, with the local arm also represented. The spiral arms were assumed to be dominated by younger stars. The spiral arms were found to greatly improve the model fit at lower galactic latitudes; (5) molecular ring—we assumed that sources were present in a ring coincident in position with the molecular ring. This component was also assumed to be dominated by young stars. The model fit at K and at the *IRAS* wavelengths was improved by the inclusion of this component.

The model also treats extinction. The dust in our Galaxy was assumed to have the same geometrical distribution as the disk stars, but to have a small scale height, comparable to that of the youngest stars.

We represent each of the distinct galactic components by up to 87 types of galactic source, each fully characterized by disk scale heights, space densities, absolute magnitudes (and dispersions in magnitude) at *BVJHK*, 12, and 25 μm, and a characteristic LRS spectrum. The geometry adopted in our model, and the content of our galactic source tables were guided by a parallel Monte Carlo simulation of the Galaxy at 12 μm (Volk et al. 1989, this volume). The luminosity functions implicit in our source tables closely match the Volk et al. 12 μm luminosity function, as well as V and K luminosity functions.

3. EXTRAGALACTIC SOURCES

Our model predicts counts from extragalactic sources for the *IRAS* 12 and 25 μm passbands and for LRS passbands. We assumed that extragalactic sources are evenly distributed over the sky, and derive 12 and 25 μm luminosity functions (and when necessary, an LRS passband luminosity function) from the 60 μm extragalactic luminosity function of Soifer et al. (1987). Close to the plane, the Galactic sources heavily dominate the extragalactic sources, but at high galactic latitudes, and especially at 25 μm, the extragalactic sources are more important. The model predicts that near the poles, extragalactic sources will dominate for $F_\nu(12\ \mu m) \lesssim 0.002$ Jy and for $F_\nu(25\ \mu m) \lesssim 0.05$ Jy (see Fig. 1).

4. RESULTS

We have compared the source counts predicted by the model with the *IRAS* observed source counts in the 12 and 25 μm passbands over the whole sky. For $|b| > 4°$, the model fits the observed *IRAS* source counts extremely well, except in certain areas (e.g., LMC, Taurus, Orion). For $|b| < 4°$, the fit is in general very good, but there are a few regions (e.g., Cygnus, Carina) where the model fit is less good. In these regions, the source counts predicted by the model fall short of the observed source counts by up to a factor of 2 at 25 μm. In general, these deficiencies are worse at 25 μm than at 12 μm. We attribute these deficiencies to the difficulty in representing the spiral arms (and young population) by analytical functions, and also to local influences. We have also compared the model predictions with the K star counts of Eaton et al. (1984) and found a good match.

In Figure 1, we show an example of the model output. The model prediction is compared to the observed *IRAS* PSC source counts for a region near the south galactic pole. This figure illustrates the way in which the model can be used to predict source counts at far lower flux levels than *IRAS*; the model is therefore likely to be useful for planning future IR space experiments.

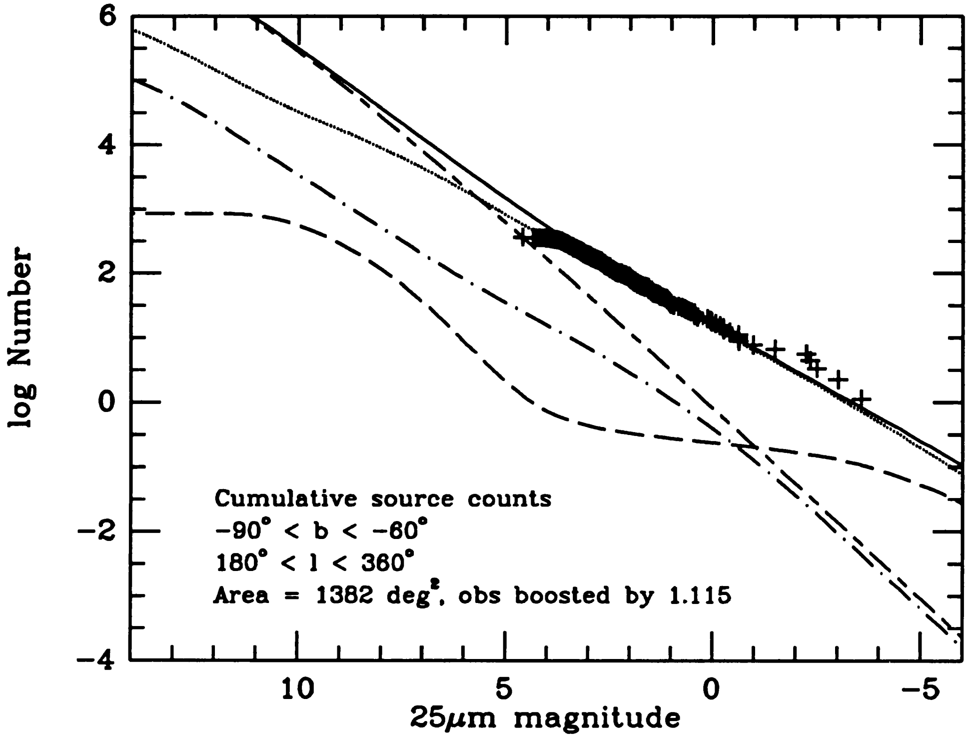

Figure 1. Comparison of model prediction and observed *IRAS* source counts for a field located near the south galactic pole. The x-axis shows the 25 μm magnitude and the y-axis shows cumulative source counts. The crosses represent the actual *IRAS* source counts, the dotted line represents the contribution from the disk, the dot-dash line the stellar halo, the long-dash line the spiral arms, the long dash-short dash line the extragalactic sources, and the solid line the total from all components. An appropriate scaling factor has been applied to the observed counts to compensate for the small gap in *IRAS* coverage in this area.

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