SELECTED AREA GALACTIC SURVEY WITH ISOCAM*

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ABSTRACT

A number of fields along the Galactic plane were imaged by Infrared Space Observatory's camera ISOCAM between April and September 1996 with the objective to observe the large scale properties of the Galaxy. Seven fields in the inner Galactic plane were imaged in the LW3 (12-18 μm) and LW7 (8.5-11 μm) filters by raster scanning a 6 $\times$ 6 field with 100 arcsec spacing between samples. Five of the fields are at b = 0 deg between 4 and 28 deg longitude; two others straddle the center at b = $\pm$ 3 deg. The data have been processed with version seven of the pipeline and potential sources have been identified in the scanned fields using the ISOGAL source extractor. Between 134 and 194 LW3 sources were extracted in the $11.6 \times 11.6\,\mathrm{arcmin}^2$ fields, and between 182 and 289 LW7 objects. The completeness limiting flux is approximately 10 mJy. The systematically higher number of LW7 sources compared to LW3 is expected owing to the stronger emission at shorter wavelengths: Point sources that were only detected in LW7 have usually a counterpart in LW3 which is just below the flux needed for a proven detection. In general there is a good correlation between the fluxes measured in the two filters in every field and between the observed source counts and the numbers predicted with a model originally tested against IRAS data. Hence the GPSURVEY data produced a reliable determination of the number of foreground stars in the infrared sky.

Key words: ISO; infrared astronomy; galactic structure; stars.

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1. INTRODUCTION

The determination of the spatial distribution of stars in our Galaxy is a problem with a long history. A fundamental difficulty in this "classical" stellar statistics is the extinction of star light caused by interstellar dust which limits star counts at visible wavelengths to relatively high Galactic latitudes or small windows near the plane. As this extinction decreases with increasing wavelength, radio and infrared observations were used in order to investigate the Galactic structure at large distances and close to the Galactic plane. These wavelengths, however, probe different Galactic constituents than the visible: Whereas the latter is dominated by ordinary stars, the radio directly traces the distribution of gas, and the mid-infrared preferentially detects dust heated by nearby stellar objects. From these observations it was inferred that our Galaxy is a mildly barred spiral.

Detailed characterizations of the global distribution of stars in our Galaxy were set about by introducing various models of the near- and mid-infrared sky. Earlier surveys in the near-infrared suffered either from too low sensitivities or from too coarse resolution to accurately model the structure of the Galaxy. This drawback will be met with the DENIS and 2MASS surveys. At mid-infrared wavelengths our knowledge is mainly based on star counts from the IRAS Point Source Catalog (PSC), but unfortunately IRAS data products are often confusion limited along the Galactic plane and contain only objects with fluxes above ≈ 1 Jy.

With the observations discussed in this paper it was possible to check the validity of models for the mid-infrared point source sky at lower fluxes. We chose for the comparison between observation and theory a modified version of the SKY model (Wainscoat et al. 1992, Cohen 1994, Cohen 1995). The authors built an ab initio statistical model of the point source sky and tested it extensively against IRAS source counts. Cohen (1993) extended the model's synthetic spectral library from 2.0 to 35.0 μm. This range covers in particular the ISOCAM filters LW3 and LW7 that were used in our observations.

2. OBSERVATIONS AND DATA PROCESSING

The observing strategy consisted of sampling a number of critical positions in the Galactic plane with ISOCAM raster scans. The positions of the fields analyzed are given in table 1.

Table 1. Central positions of the rasters in the GP-SURVEY program.

OSN	latitude b	longitude l	Rev. no.
1	$-0.^{\circ}1$	$+5.^{\circ}2$	148
2	$+0.^{\circ}3$	$+15.^{\circ}9$	148
3	$+0.^{\circ}6$	$+28.^{\circ}1$	152
4	$+0.^{\circ}3$	$-28.^{\circ}8$	273
5	$0.^{\circ}0$	$-15.^{\circ}7$	289
6	$+0.^{\circ}1$	$-6.^{\circ}0$	391
7	$+3.^{\circ}1$	$0.^{\circ}0$	301

Each raster consisted of 6×6 images, separated by 100 arcsec in spacecraft y- and z-axis. This way we covered an area of 135 arcmin^2 in an observation of two hours duration. The images were taken with the Astronomical Observation Template CAM01 using filters LW3 and LW7. They cover the wavelength ranges 12-18 μm and 8.5-10.7 μm, respectively. The pixel field of view was 6 arcsec.
The starting point of the data processing were Auto Analysis Results from pipeline version seven. For the extraction of point sources we used an algorithm developed for the ISOGAL project (Alard et al. 1999); this is an observing program similar to GPSURVEY (Omont 1999). It contains inter alia corrections for the distortion of the ISOCAM field of view and for transient effects. Spot-checks of the lists produced were then carried out with the ISOCAM Interactive Analysis software (Ott et al. 1996) in order to test the reliability of the source extraction. In each field we detected more sources in filter LW7 than in filter LW3, as expected because of the shorter wavelength. Therefore it was possible to check the completeness of the LW3 source list by means of cross-identification with LW7. We found for 86 per cent of the sources stronger than 10 mJy in LW3 a counterpart in LW7, hence the source extraction worked in a satisfactory way down to that flux level.

3. RESULTS

Figures 1-4 show for two typical fields the comparison of the star counts from the ISOCAM observations with the SKY 5 model. The good agreement is representative also for other fields. For fluxes below 8^m (= 13 mJy) in LW3 and below 9^m (= 11 mJy) in LW7 the accumulated observed source counts remain constant whereas the model predicts a further linear increase of log N as a function of -log S (we assumed here zero magnitude fluxes of 20.5 Jy and 43.4 Jy respectively). These deviations are caused by incomplete detection of the weakest sources. Also in the flux range just below 1 Jy systematically less sources were observed than what the model predicts. This may be due to a selection effect, because we had to choose the position of the fields in the Galactic plane so that saturation of the ISOCAM detectors which happens in our filters for fluxes above ≈ 1 Jy was by all means avoided. In the intermediate flux range the observed source counts lie only a little below the SKY 5 predictions: The difference is about 30 per cent in LW3 and 20 per cent in LW7.
The source densities in our fields range between 3600 and 5200 deg^{-2} for LW3 and between 4900 and 7700 deg^{-2} for LW7; this is not far from the confusion limit. The differences between source counts at various positions are small, nevertheless we found a significantly higher source density e.g. for the field at l = -6 deg than for the field at l = +28 deg. This is due at least partially to the increased contribution from bulge populations.

4. CONCLUSIONS

We extended the range of fluxes S for source counts N in the mid-infrared by two orders of magnitude compared to what was known from IRAS. Because of the high sensitivity and spatial resolution provided by ISOCAM, it became possible to check the extrapolations in the SKY 5 model. Several fields in the Galactic plane were scrutinized and satisfactory agreement was found between observations and the model for the flux range 10-300 mJy. This result is similar to findings in the near-infrared (Ruphy et al. 1997).
From a comparison of the source lists for the two different filters we conclude that we have reached a high level of completeness in the LW3 filter down to 10 mJy. This is in good agreement with the limit found in the ISOGAL fields which were observed with a similar strategy (Omont et al. 1999). As more sources were found in LW7 than in LW3, we assume that the completeness limit in that filter is ≤ 10 mJy as well. The small differences between observed and predicted source counts between 10 and 300 mJy are barely significant considering the uncertainty of 30 per cent in the photometric accuracy of ISOCAM.
Future work, however, will be needed to clarify the reason for the small discrepancies in the slopes of the log N vs. log S plots between model and observation. If improved photometry shows that they are real, we can probably use the observed source counts to put new quantitative constraints on the attributes and population content of the geometric components in the model. Besides, it is planned to determine the nature of the sources seen by using also data from 38 additional pointed observations. They were taken with filters LW3, LW4 (5.5-6.5 μm) and LW7 at various other positions in the Galactic plane. These positions are more or less randomly distributed, since they were made to coincide with ISOCAM parallel mode observations. Hence they can also be used to check for the above-mentioned selection effects in the raster observations: If they agree better with the model, then the discrepancies discussed in this paper are likely due to the avoidance of bright sources with the raster scans, otherwise the model is off.

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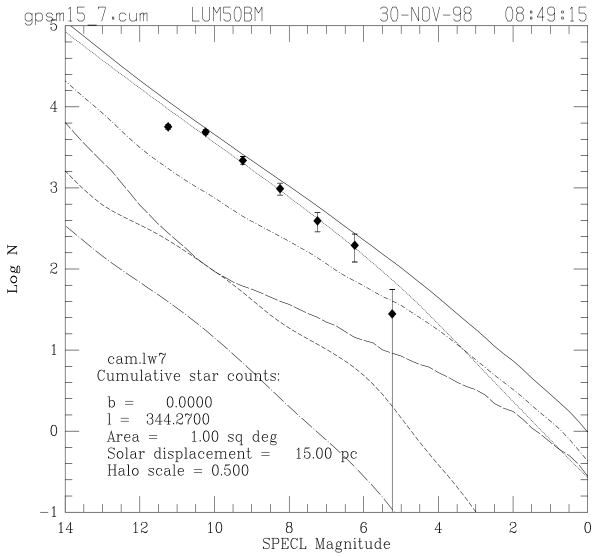

Figure 1. Comparison of SKY predictions and GP-SURVEY observed cumulative star counts at 9.62 micron for a field centered at b = 0.0 degree, l = -15.7 degree. Diamonds, observed star counts; solid line, total model prediction; dots, disk; dot-dash, bulge; long dash, arms; dash, ring; dot-long dash, halo.

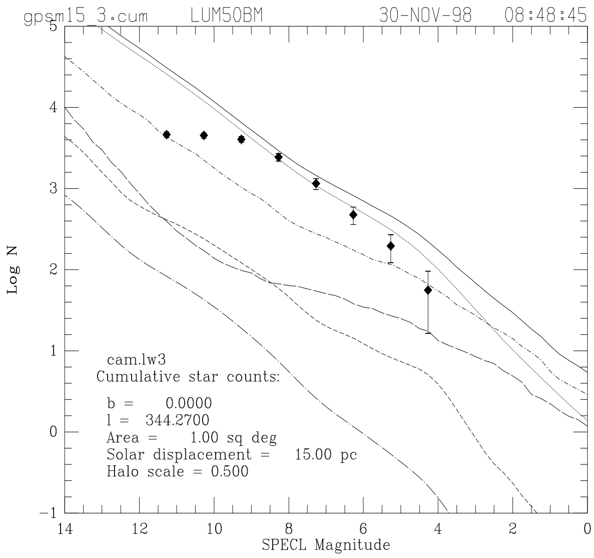

Figure 2. Comparison of SKY predictions and GP-SURVEY observed cumulative star counts at 15 micron for a field centered at b = 0.0 degree, l = -15.7 degree. Diamonds, observed star counts; solid line, total model prediction; dots, disk; dot-dash, bulge; long dash, arms; dash, ring; dot-long dash, halo.

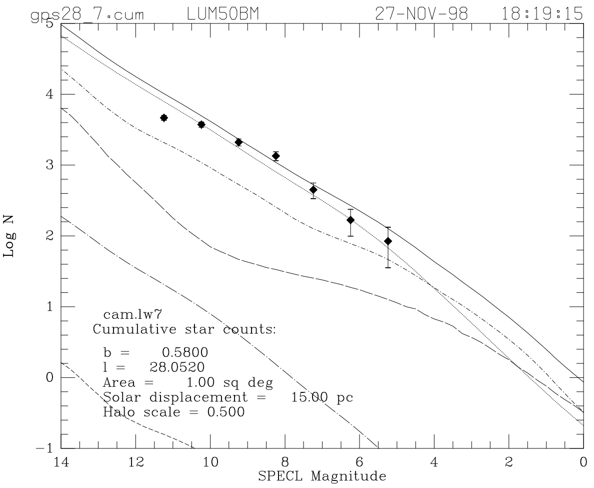

Figure 3. *Comparison of SKY predictions and GP-SURVEY observed cumulative star counts at 9.62 micron for a field centered at b = 0.6 degree, l = +28.1 degree. Diamonds, observed star counts; solid line, total model prediction; dots, disk; dot-dash, bulge; long dash, arms; dash, ring; dot-long dash, halo.*

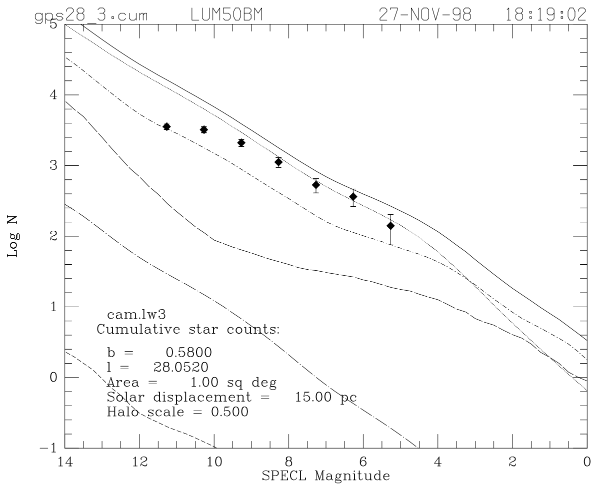

Figure 4. *Comparison of SKY predictions and GP-SURVEY observed cumulative star counts at 15 micron for a field centered at b = 0.6 degree, l = +28.1 degree. Diamonds, observed star counts; solid line, total model prediction; dots, disk; dot-dash, bulge; long dash, arms; dash, ring; dot-long dash, halo.*