MONTE CARLO SIMULATIONS OF THE GALAXY AT 12 μm: IMPLICATIONS FOR GALACTIC STRUCTURE

K. Volk, R. J. Wainscoat, M. Cohen, H. J. Walker, and D. E. Schwartz
NASA Ames Research Center
Moffett Field, CA 94035 USA

ABSTRACT. We present an all-sky star count model at 12 μm based upon the *Infrared Astronomical Satellite* (*IRAS*) observations that characterize both the 12 μm luminosity function and the geometrical parameters of the galaxy. The model includes five galactic components: the bulge, the spheroid, the exponential disk, the spiral arms, and the molecular ring. The distribution of the brighter *IRAS* sources along the galactic plane required that the model include sources within the spiral arms and the molecular ring to produce an acceptable fit. We do not support the conclusion of Habing (1988) that the galactic disk ends just outside the solar circle, and do not require a thick disk to match the observations. We suggest that Habing's sample includes *IRAS* sources in the spiral arms but his model for the galactic disk does not include this critical component.

1. INTRODUCTION

One of the first results to emerge from the *IRAS* survey data was that specified subsets of the sources clearly delineate the disk and the bulge of the galaxy. Habing (1988) has studied the sky distribution of these sources. He concluded that the galactic disk ends at about 9.5 kpc radius and inferred a contribution from a component of large scale height which he tentatively identified with the thick disk. It is important to verify these results and see if they apply to all *IRAS* sources. This paper briefly presents some results of an analysis of all *IRAS* 12 μm point sources based upon a Monte Carlo model of the galaxy. A full description of the model and its results is in preparation.

2. THE GENERAL GALAXY MODEL

For these models we have determined the 12 μm luminosity function. At low luminosity it was determined by transforming the V luminosity function to 12 μm using V – [12] colours for bright stars. We checked this using stars from the *Catalogue of Nearby Stars* (Gliese 1969). At high 12 μm luminosities, a lower limit to the function was found from OH/IR stars with phase-lag or kinematical distances. At high 12 μm luminosities the V → [12] transformation fails because the sources are optically faint. That part of the final luminosity function was determined from detailed comparison of the model predictions with the observed bright *IRAS* sources.

In the models we included the normal exponential disk of 3.5 kpc scale length, a de Vaucouleurs spheroid of effective radius 2.7 kpc and axis ratio 2.0, and a bulge component of the functional form given by Bahcall (1986, Table 1) but with normalization radius 2.0 kpc and axis ratio 1.6 determined from analysis of *IRAS* bulge sources. For the spiral arm component we used a least-squares fit to the results of Georgelin and Georgelin (1976) assuming the arms to be symmetric on the near and far sides of the galactic center. We also required a ''molecular'' ring component, Gaussian in radial density distribution, peaking at 0.45 $R_{\odot}$ with FWHM of 0.15 $R_{\odot}$. Only high luminosity sources were included in the spiral arms and the molecular ring. We assumed $R_{\odot} = 8.5$ kpc. The component geometries are illustrated in Figure 1, which

S. Bowyer and C. Leinert (eds.), The Galactic and Extragalactic Background Radiation, 121–122.

gives the model predictions for an *IRAS* type satellite observing the galaxy from S Dor in the Large Magellanic Cloud. The solar position would be approximately latitude –0.29°, longitude –9.88°. Generally a maximum disk radius of 15 kpc was used although values from 10 to 25 kpc were tried in various runs.

The disk scale height was assumed to be 120 pc for stars of spectral type earlier than A0, 300 pc for later type main sequence stars, 250 pc for red giant stars, and 120 pc for the high luminosity spiral arm or molecular ring sources.

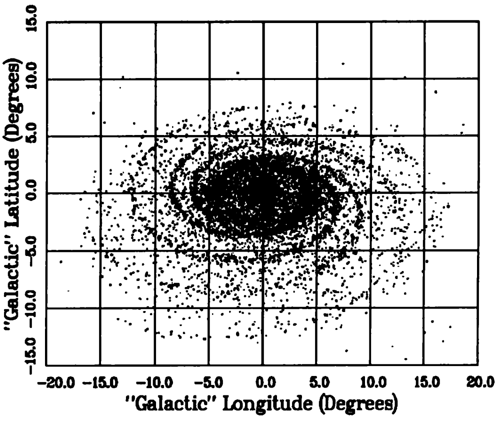

Figure 1. The predicted 12 μm point sources observable from Large Magellanic Cloud, to illustrate the model components.

3. RESULTS OF THE MODELS

The models were compared in detail with the *IRAS* data for nine areas of the sky, from the two galactic poles to areas on the galactic plane, correcting where necessary for contributions due to extragalactic sources and for gaps in sky coverage. In addition the brightness distribution and sky distribution for all the predicted sources brighter than 2.5 Jy at 12 μm were compared with the *IRAS* observations. The slope of the luminosity function for bright sources was found to be directly proportional to the log (N)-log (S) slope for areas in the galactic plane, which are completely dominated by high luminosity sources. Further, it was not possible to properly fit the galactic anticenter with a maximum disk radius of 9.5 kpc as was found by Habing (1988). Any such model had a severe deficiency of sources in the outer galaxy.

Our models did not require a disk component of large scale height to fit any of the test areas, including an intermediate latitude area looking towards the inner galaxy where we would expect any thick disk component to have an effect. A thick disk could be accommodated in the models if the relative number of sources were low, but there is no evidence that such a component is needed based upon our results.

The spiral arms and the molecular ring were vital in fitting the sky distribution of bright *IRAS* sources. We suggest that the conclusion of Habing (1988) that the disk ends just outside the solar circle is the result of the contrast between the spiral arms and the molecular ring in the inner galaxy and the relatively weak spiral arm and exponential disk contributions in the outer galaxy. For a simple exponential disk this high contrast requires a small outer radius.

REFERENCES

Bahcall, J. N. 1986, *Ann. Rev. Astron. Astrophys.*, **24**, 577.
Georgelin, Y. M. and Georgelin, Y. P. 1976, *Astr. Ap.*, **49**, 57.
Gliese, W. 1969, *Veroffentl. Astron. Rechen-Institus Heidelberg*, No. 22.
Habing, H. 1988, *Astr. Ap.*, **200**, 40.