Bull. Astr. Soc. India (2003) 31, 407–410

Warp of the Galactic Disk as seen in Mid Infrared from Midcourse Space Experiment

S. Vig*, S.K. Ghosh, D. K. Ojha
Tata Institute of Fundamental Research, Mumbai (Bombay) - 400 005 (India)

Abstract. The nature of the warp structure in the distribution of stellar as well as warm interstellar dust (WISD) components in the Galactic disk has been investigated using respective mid infrared emissions. Such a study with high angular resolution has only recently become possible with the advent of Galactic plane survey in four major bands (8, 12, 14 & 21 μm) by the Midcourse Space Experiment (MSX). The MSX Point Source Catalog as well as the panoramic images have been used here. Various measures representing the location of the mid-plane for the stellar and WISD components have been extracted. The resulting mid-plane latitude versus longitude data have been fitted well with a simple sinusoidal function to look for a warp signature (WS). The WS has been clearly detected in all the four bands for both the stellar as well as the WISD components with similar phases but amplitudes ranging from $0.2^\circ - 0.5^\circ$ in latitude. Our results have been compared with those from other studies of similar measures of WS.

1. Introduction

The plane of our Galaxy exhibits a warped structure. The Galactic plane curls down on one side and curls up on the other side like an integral sign. Our objective is to look for warp signature in the stellar component as well as warm interstellar dust heated by local radiation field using the recently available mid infrared data sets from the Midcourse Space Experiment, (MSX) Galactic plane survey (Price et al, 2001). For the analysis of warp, we have used the MSX data of the four most sensitive mid infrared bands A, C, D and E with λ corresponding to 8.28, 12.13, 14.65, and 21.34 μm, respectively. The source counts were obtained from the MSX Point Source Catalog Version (MSX PSC) of the Galactic plane. The PSC source sample considered for the present analysis, after the application of our selection criteria, are 164723, 25467, 18239 and 14254 in 8, 12, 14 and 21 μm band respectively. For diffuse emission, the imaging data from the MSX Galactic plane survey in four bands have been utilised. Thirty six lower resolution $10^\circ \times 10^\circ$

*e-mail: sarita@tifr.res.in

images with pixel size 36″×36″, generated in each band, that span the full latitude and longitude range of the survey were used.

2. Analysis and Results

Most of the point sources in our sample are stellar sources. The present study of point sources restricts the latitude range for analysis to $|b| \leq 2.75°$. The sample of stars, for each band, is binned in bins of 10 degree longitude. For each bin, the mean latitude as well as the median latitude of stellar sources are computed in each band.

For the diffuse emission in all four bands, we consider 36 longitude bins of 10° each. The contribution of point sources from the PSC are subtracted out from the total emission to estimate the diffuse component. Two sets of data are considered here, one for $|b| \leq 5°$, and the other for $|b| \leq 2.75°$. Once the binning is accomplished, for each longitude bin, the intensity weighted central latitude as well as a median latitude are computed.

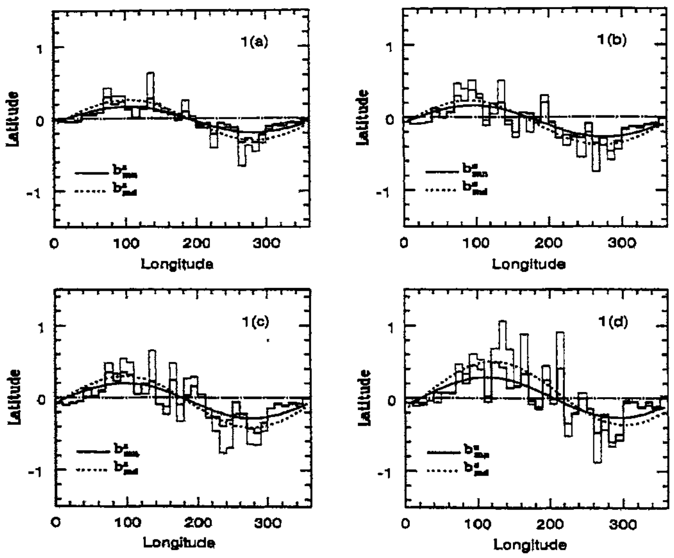

Figure 1. The variation of mean and median Galactic latitude as a function of longitude for stellar sources, for (a) 8 μm, (b) 12 μm, (c) 14 μm, and (d) 21 μm band. The histograms and the smooth curves represent the measurements and the fitted functions respectively. The thick solid line histogram and the solid line sinusoid represent the mean, and the best fit to the mean Galactic latitude, respectively. The thin line histogram and the dotted line sinusoid represent the median, and the best fit to the median Galactic latitude, respectively.

For both the stellar and diffuse emission cases in every band, a simple model has been be used (Djorgovski & Sosin, 1989) to fit the data as a sine function of the form $b(l) = b^0 \times \sin(l - \phi) - z$

where b represent the best fit to the mean (median). The parameters b^0, ϕ, quantify the warp signature (WS), indicating the amplitude and phase; and z represents any possible offset of the entire Galactic midplane. The best fit parameters have been extracted using a non-linear least square fitting procedure giving equal weightage to each longitude bin. In addition, to explore the absence of WS, *viz.* a 'null' hypothesis, we attempt to fit a constant function of the form, $b(l) = k$.

Selected results are presented here. While figure 1 displays the variation of mean and median latitude as a function of Galactic longitude in histogram form for the stellar sources, figure 2 shows the case of diffuse emission from the warm interstellar dust component. There is a clear signature of the warp in all the four bands, as is evident from the fact that the sinusoid fits the data better than null hypothesis in all the cases.

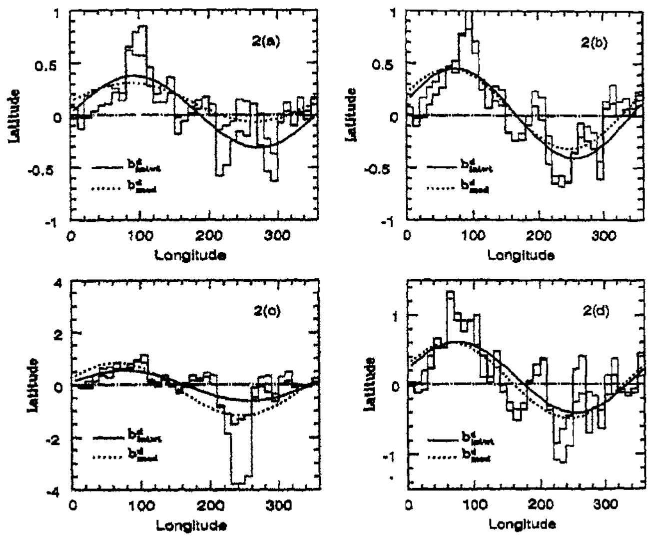

Figure 2. The variation of intensity weighted central latitude and median Galactic latitude as a function of longitude for the diffuse emission from warm interstellar dust in the latitude range $|b| \leq 5°$, for (a) 8 μm, (b) 12 μm, (c) 14 μm, and (d) 21 μm band. The thick solid line histogram and the solid line sinusoid represent the intensity weighted central latitude, and the best fit to the intensity weighted Galactic latitude, respectively. The thin line histogram and the dotted line sinusoid represent the median, and the best fit to the median Galactic latitude, respectively.

3. Comparison with other Results

It is of interest to note that the warp signature for the stars as obtained by us is consistent with that obtained by Djorgovski & Sosin (1989) from IRAS PSC sources. The present WS in the mid infrared waveband is also qualitatively consistent with that obtained from the analysis of the near

Table 1. Comparison of parameters of warp signature (amplitude and phase) for the Galactic disk obtained from different studies.

Band	Wavelength	Survey	Component	Amplitude	Phase	Peak	Ref. no.
NIR	2.2 μm	2MASS	Stellar		85° ± 5°	+ve	4
NIR	2.2 μm	DENIS	Stellar	~ 2.5°	266.1°*	−ve	1
NIR	1.25-4.9 μm	DIRBE	Stellar	0.4°-0.6°	74°-116°	+ve	3
MIR	8.3-21.3 μm	MSX	Stellar	0.2°-0.4°	78°-113°	+ve	This work
MIR-FIR	12-60 μm	IRAS	Stellar	0.2°-0.3°	90°-100°	+ve	2
Radio	21 cm	H I	Atomic gas	1.3°	80° ± 5°	+ve	7
mm	2.6 mm	CO	Molecular gas	~ 1.5°+	270°*	−ve	5
MIR	8.3-21.3 μm	MSX	Warm dust	0.2°-0.4°	65°-116°	+ve	This work
FIR	240 μm	DIRBE	Cold dust	1.0°	80°-100°	+ve	3

* The quoted amplitude corresponds to this longitude.
\+ The number quoted is calculated based on the data of May et al. (1997); at R~19 kpc.

infrared DIRBE data by Freudenreich et al (1994), some differences arising due to the different methods of analysis. Table 1 presents an overall comparison between our results and the warp signature parameters obtained by other studies.

References

Derriere, S., Robin, A. C. 2001, *The New Era of Wide Field Astronomy*, ASP Conf. Ser., **232**, 229, (eds.) R. G. Clowes, A. J. Adamson, & G. E. Bromage

Djorgovski, S., Sosin, C. 1989, *Astrophys. J.*, **341**, L13

Freudenreich, H. T., Berriman, G. B., Dwek, E., et al. 1994, *Astrophys. J.*, **429**, L69

Lopez-Corredoira, M., Caberra-Lavers, A., Garzon, F., Hammersley, P. L. 2002, *Astron. & Astrophys.*, **394**, 883

May, J., Alvarez, H., Bronfman, L. 1997, *Astron. & Astrophys.*, **327**, 325

Price, S. D., Egan, M. P., Carey, S. J., Mizuno, D. R., Kuchar, T. A. 2001, *Astrophys. J.*, **121**, 2819

Weaver, H., Williams, D. R. W. 1973, *Astron. & Astrophys. Suppl.*, **8**, 1