NEAR-INFRARED STUDIES OF THE MILKY WAY

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The inner region of the Galaxy has been explored by means of near-infrared observations; the distribution and population of the stars are studied from the near-infrared brightness mapping and star counts in the Milky Way, while the magnetic-field configuration is probed by the near-infrared polarimetry.

1. DISTRIBUTION AND POPULATION OF THE STARS

A series of balloon observations of the 2.4μm brightness distribution in the galactic plane have thrown light on the stellar distribution in the inner Galaxy (e.g. Okuda 1981). An interesting result was the fact that there exists an active arm located at about 5 kpc from the Galactic Center. From the extremely strong concentration of the emission into the galactic plane, it has been suggested that the contributing stars are a young population, rich in M-supergiants (Maihara _et al_. 1978, Hayakawa _et al_. 1977, 1981). It was however hard to identify them to specific type of stars only from the observations of integrated radiation in the wide field of view, and in a single band.

As a follow-up observation, we have made near-infrared source counts by using a multi-color photometer with I, H, K, and L bands that should be more informative for the identification. The source counts were carried out in 17 strips across the galactic plane between $\ell=350^{\circ}$ and $\ell=45^{\circ}$. Preliminary results were reported elsewhere (Kawara _et al_. 1982).

The results of the analysis are as follows:
1) General behaviour of the number density distribution of the sources is similar to the surface-brightness distribution observed by the balloons.

2) A conspicuous enhancement in the number density is found in the direction of the Galactic Center. This must be associated with the nuclear bulge, and if so, the absolute K-magnitude is estimated to be brighter than -8 mag, applying the distance modulus of 15 mag to the observed K-magnitude, 6-7. This is compatible with very luminous M-giants. They

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are more tightly concentrated towards the Galactic Center than OH/IR sources or planetary nebulae.

3) At the midst of the Galactic Center, within $\pm 0.2^{\circ}$, there is a spiky concentration of the sources, mostly with large reddening. Their absolute K-magnitude should be brighter than -10 if corrected for the distance modulus and the reddening. This indicates a clustering of M-supergiants in the galactic nucleus.

4) As was found in the 2.4μm mapping, a remarkable concentration of the sources is seen in the region $\ell=26^{\circ}$ - 28°. The sources concentrate more strongly to the galactic plane (FWHM 2°) than the 2.4μm surface brightness. A considerable fraction of the sources are highly reddened. After correction for reddening, the absolute K-magnitude of the sources is brighter than -9, compatible with very luminous M-giants or M-supergiants.

In order to make these conclusions more quantitative, we have tried to build a comprehensive model to explain the observed results of the source counts as well as the 2.4μm mapping (Kawara and Okuda, in preparation). After several trials, we find that the following assumptions are necessary for a reasonable fit to the observations.

1) In the nuclear bulge, there exists an additional concentration of luminous M-giants ($M_K \leq -9$); their relative frequency is 100 times that in the solar neighbourhood.

2) An overpopulation of luminous M-giants ($M_K \leq -9$) by a factor of 20 is also present in the 5-kpc arm.

3) The scale height of the z-distribution of the stars decreases towards the Galactic Center, where it is almost halved relative to that in the 5-kpc arm.

In Figure 1, the observed results for the latitude dependence of the surface number density are compared with the model calculations without (dotted line) and with (solid line) the extra components assumed above. The enhancement in the bulge and the clustering in the region $\ell=26^{\circ}$-28° cannot be explained without the additional bright sources. From these analyses, it is concluded that the stars with high infrared luminosity are overabundant in the bulge as well as in the 5-kpc arm. Their luminosity indicates that they correspond to M-supergiants or to the upper end of the asymptotic branch of M-giants.

2. INTERSTELLAR POLARIZATION

Interstellar polarization has been used for diagnoses of the magnetic field in the Galaxy. However, the observations so far made have been mostly in the visible range and limited to the solar neighbourhood, due to strong interstellar extinction.

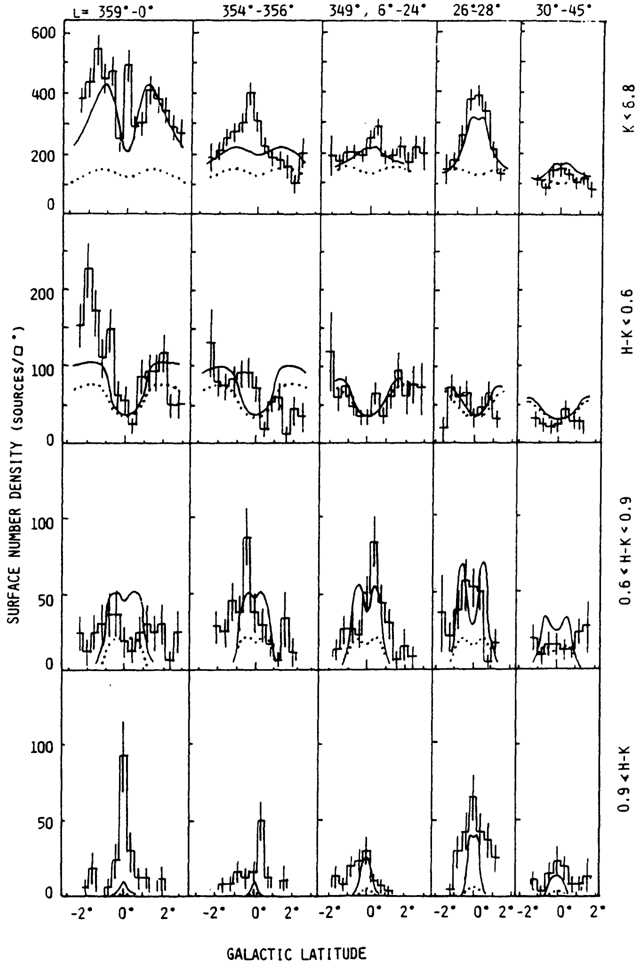

Figure 1. Surface density of infrared sources as a function of galactic latitude in various longitude intervals (top scale). Uppermost panels: total numbers of bright infrared sources. Other panels: distributions for sources in various infrared-colour ranges. Dotted and solid lines represent model calculations (see text).

By expanding the observations into the near infrared, we have succeeded to look into deep space as far as the central region of the Galaxy. Polarization was measured in the K-band for the sources in the galactic plane at $\ell=0^{o}$, 20^{o}, and 30^{o}, together with photometry in the J, H, K, and L-bands.

The observed polarizations are preferentially aligned parallel to the galactic plane and well correlated with the interstellar extinction, represented by the H-K index. The dependence of the polarization on H-K varies with galactic longitude as shown in Figure 2.

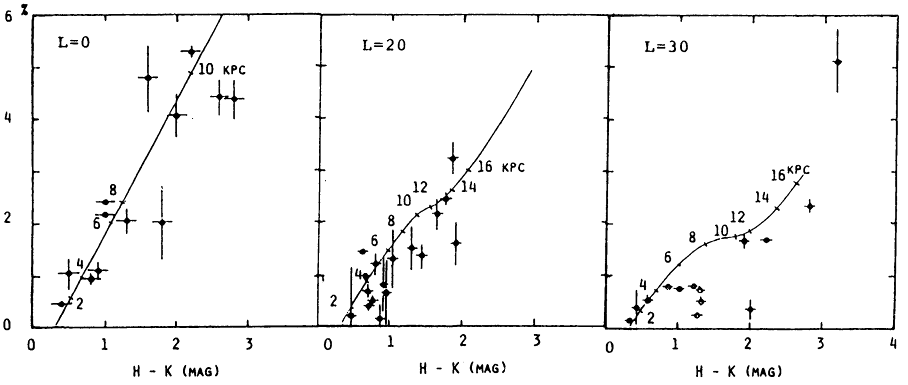

Figure 2. H - K dependence of the observed polarization in 3 longitude regions. The expected dependences are shown by curves, with distance scales estimated from the HI and CO data.

The variation can be well explained if we assume that the magnetic field runs concentric around the Galactic Center, and that the polarizing efficiency depends on the relative angle of the magnetic line of force and the line-of-sight. By using the gas density distribution in the inner Galaxy, estimated from the HI and CO observations, we correlate the H-K index with the distance, and it is found that our observations reach distances far beyond 10 kpc. This is the first evidence for the presence of a uniform magnetic field in the inner Galaxy, similar to that found in the solar neighbourhood (Kobayashi _et al_., in preparation).

Since our Galaxy is the nearest and largest edge-on galaxy, it should be an irreplaceable sample for detailed studies of galactic structure, particularly in the z-direction. As is shown above, near-infrared observations can become a powerful tool for such investigation.

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