VERTICAL METALLICITY GRADIENT OF THE GALAXY BASED ON UBV STARCOUNT DATA

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ABSTRACT. The spatial distribution of metal abundance in the Galaxy has been analyzed using the UBV starcount data recently obtained in two high-latitude regions of the North Galactic Pole (NGP) and Selected Area 54 (SA54).

A least-squares analysis was performed to determine the vertical metallicity gradient for each of the thin and thick disk components that gives a reasonable fit to the observed U-B and B-V colour distributions to V = 18 mag. The most probable value of the vertical gradient is obtained as $d[Fe/H]/dz$ = -0.5 kpc^{-1} for the thin disk, and -0.1 kpc^{-1} for the thick disk.

1. Introduction

Wide-area UBV starcount data are useful in analyzing the detailed structure of stellar populations in the Galaxy. While the B-V colour distribution for stars determines the spatial distribution of stellar density, the U-B colour distribution determines the spatial distribution of the metal abundance because of the sensitivity of the U-B colour to the variation of metal abundance. Therefore, in order to obtain a better understanding of the large-scale distribution of density and metallicity in the Galaxy, both the U-B and B-V colour distributions based on a large, complete sample of stars is necessary.

There are only two regions where stars were surveyed over more than 10 square degrees to V = 18-19 mag with accurate photometry in the UBV colour bands. One is the NGP region for a sample of 18,000 stars to V = 19 mag in 21.5 square degrees (Yoshii et al. 1987), and the other is the SA54 region for a sample of 7600 stars to V = 18 mag in 16 square degrees (Yamagata & Yoshii 1992). Using these UBV data together with wide-area BV data in other fields available to date, Yamagata & Yoshii (1992) determined the structural parameters of the thin-disk, thick-disk, and spheroid components with their metallicity gradients taken from the literature.

In this paper, not assuming the metallicity gradients in advance, we derive the vertical metallicity gradients of the thin and thick disks by performing a least-squares fit to the U-B colour distributions in the NGP and SA54. This is a preliminary report and the details will be published elsewhere.

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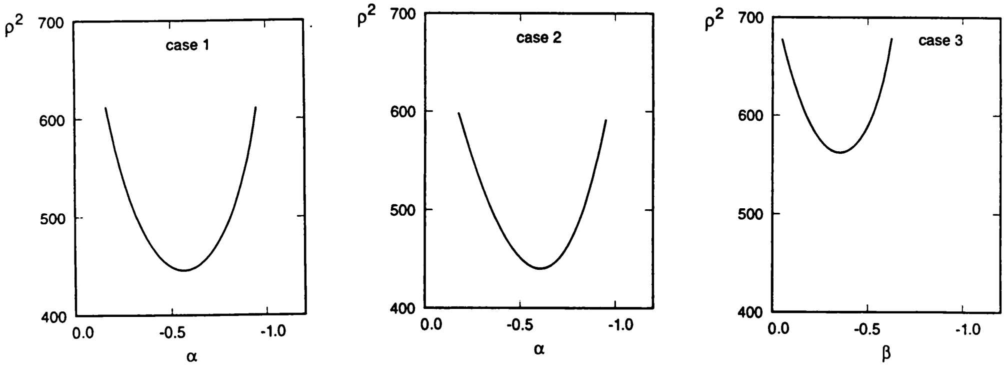

Figure 1. The least-squares sum, ρ^2, for the SA54 versus metallicity gradient of the thin disk, α, for cases 1 and 2, and ρ^2 versus mean metallicity of the thin disk, β, for case 3. The behaviour of ρ^2 for the NGP is almost the same as for SA54.

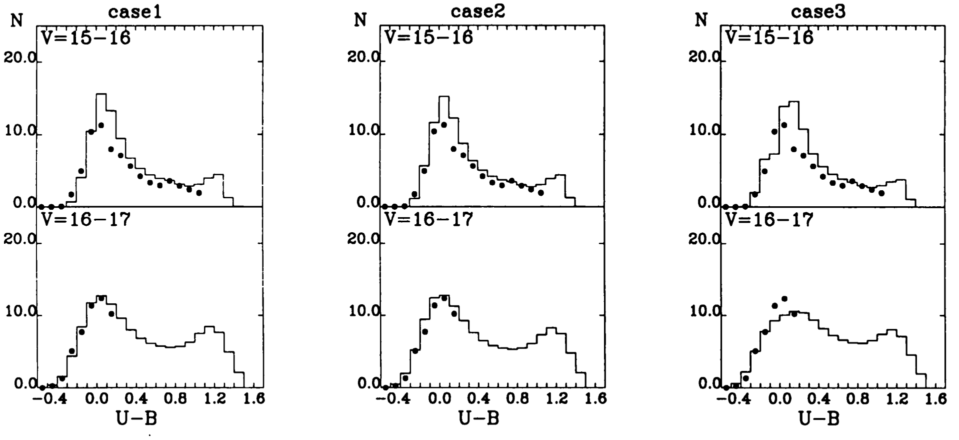

Figure 2. The U-B colour distribution for SA54 at colour intervals of 0.1 mag as a function of apparent V magnitude for 15-16 (upper panel) and 16-17 (lower panel) for cases 1, 2 and 3. Filled circles and histograms show the data and model predictions, respectively.

2. Metallicity Gradient

When the starcount data are plotted in a two-colour (U-B) - (B-V) diagram, it is clearly seen that the average ultraviolet excess of stars monotonically increases as a function of apparent V magnitude (e.g. Yoshii et al. 1989; Stobie & Ishida 1987). This fact indicates that the vertical metallicity gradient exists, because metal-weak stars with large ultraviolet excess become dominant as they locate far from the disk plane and therefore become faint.

The following three cases of the metallicity distribution are considered to find the most probable case by applying a least-squares method:

1) the vertical metallicity gradient of the thin-disk component is a parameter to be solved. The vertical metallicity gradient of the thick-disk component is fixed as $d[Fe/H]/dz = -0.1$ kpc^{-1}, but its metallicity extrapolated onto the disk plane is a parameter to be solved;
2) the vertical metallicity gradient of the thin-disk component is a parameter to be solved. The thick-disk component has no vertical metallicity gradient, and its mean metallicity is a parameter to be solved;
3) both the thin- and the thick-disks have no vertical metallicity gradients, and their respective mean metallicities are parameters to be solved.

We calculated sums of squares of residuals between the observed and predicted numbers of stars divided into 0.1 mag colour bins at intervals of 1 mag for apparent V magnitude. The summation runs over $-0.4 < B\text{-}V < 2.0$ for $13 < V < 17$, $-0.4 < B\text{-}V < 0.7$ for $17 < V < 18$, $-0.8 < U\text{-}B < 1.6$ for $13 < V < 16$, and $-0.8 < U\text{-}B < 0.2$ for $16 < V < 17$. Then, in the accessible space of the two parameters considered for each of the above three cases, we try to find the parameter set that minimizes the least-squares sum, ρ^2.

Figure 1 shows a trajectory of ρ^2 as a function of one of the surveyed parameters for a sample of SA54 stars. The case 3, where a constant metallicity is assumed for the thin and thick disks, is obviously not acceptable because of the considerably large value of ρ^2. The least-squares sums for cases 1 and 2 have nearly the same minimum for both the NGP (not shown) and SA54.

Figure 2 shows the comparison of the observed starcount data (filled circles) and the model calculations (histogram) for each of the cases 1 to 3. The upper panel shows the U-B colour distributions for $15 < V < 16$, and the lower panel for $16 < V < 17$. Fairly good agreement is apparent for the cases 1 and 2 as expected.

Among the above three cases of metallicity distribution, case 3 is ruled out, but the least-squares sum alone cannot distinguish between cases 1 and 2. We note, however, that in case 1 the solved values of the parameters for SA54 are almost the same as those for the NGP. On the contrary, in case 2 there is no consistency between the solved values of the parameters in the NGP and SA54. We therefore conclude that case 1 is the most likely and in this case the probable value of the metallicity gradient is $d[Fe/H]/dz = -0.5$ kpc^{-1} for the thin disk and -0.1 kpc^{-1} for the thick disk.

References

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