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PROPER MOTIONS IN THE GALACTIC BULGE: PLAUT'S WINDOW

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RESUMEN

Un estudio de movimientos propios en un campo de $20' \times 20'$ dentro de la ventana de baja extinción de Plaut (l,b)=$(0°, -8°)$ ha sido completado. Movimientos propios relativos y fotometría fotográfica BV han sido obtenidos para $\sim 21,000$ estrellas con una diferencia de época de 21 años y hasta $V \sim 20.5$ mag. Los errores de movimiento propio son típicamente de 1 mas año^{-1}. Tras una correlación cruzada con el catálogo 2MASS se obtuvo una muestra de ~ 8700 estrellas, de las cuales dos muestras dominadas por disco y bulbo respectivamente, fueron sustraídas en base al diagrama color-magnitud JH. Las dos muestras exhiben diferentes distribuciones de movimiento propio, con el disco mostrando el conocido reflejo del movimiento solar. La rotación galáctica también fue observada en aquellas estrellas ubicadas entre $\sim$2 y $\sim$3 kpc de distancia. La muestra del bulbo, representada por gigantes rojas, tiene una dispersión intrínseca de movimiento propio de $(\sigma_l, \sigma_b) = (3.39, 2.91) \pm (0.11, 0.09)$ mas año^{-1}, la cual está en buen acuerdo con resultados previos. Una distancia media de $6.37^{+0.87}_{-0.77}$ kpc ha sido estimada para las estrellas del bulbo, basadas en la magnitud K observada del clump rojo de la rama horizontal. La distribución de metalicidad también se obtuvo para una submuestra de 60 estrellas gigantes del bulbo, basada en índices fotométricos calibrados. Los valores de $[M/H]$ observados muestran un valor máximo a $[M/H] \sim -0.1$ con una distribución extendida de estrellas pobres en metales y alrededor de un 30% de estrellas con metalicidad supersolar. No se observaron cambios en la dispersión de movimientos propios como función de $[M/H]$. Actualmente estamos procesando fotometría CCD en las bandas $UBVRI$ para todo el catálogo de $\sim 21,000$ estrellas.

ABSTRACT

A proper motion study of a field of $20' \times 20'$ inside Plaut's low extinction window (l,b)=$(0°, -8°)$, has been completed. Relative proper motions and photographic BV photometry have been derived for $\sim 21,000$ stars reaching to $V \sim 20.5$ mag, based on the astrometric reduction of 43 photographic plates, spanning over 21 years of epoch difference. Proper motion errors are typically 1 mas yr^{-1}. Cross-referencing with the 2MASS catalog yielded a sample of ~ 8700 stars, from which predominantly disk and bulge subsamples were selected photometrically from the JH color-magnitude diagram. The two samples exhibited different proper-motion distributions, with the disk displaying the expected reflex solar motion. Galactic rotation was also detected for stars between $\sim$2 and $\sim$3 kpc from us. The bulge sample, represented by red giants, has an intrinsic proper motion dispersion of $(\sigma_l, \sigma_b) = (3.39, 2.91) \pm (0.11, 0.09)$ mas yr^{-1}, which is in good agreement with previous results. A mean distance of $6.37^{+0.87}_{-0.77}$ kpc has been estimated for the bulge sample, based on the observed K magnitude of the horizontal branch red clump. The metallicity $[M/H]$ distribution was also obtained for a subsample of 60 bulge giants stars, based on calibrated photometric indices. The observed $[M/H]$ shows a peak value at $[M/H] \sim -0.1$ with an extended metal poor tail and around 30% of the stars with supersolar metallicity. No change in proper motion dispersion was observed as a function of $[M/H]$. We are currently in the process of obtaining CCD $UBVRI$ photometry for the entire proper-motion sample of $\sim 21,000$ stars.

Key Words: astrometry — Catalogs — Galaxy: bulge — Galaxy: disk — stars: kinematics

1. INTRODUCTION

All proper motion investigations of the bulge, including the one we present in this paper, more or less agree on a velocity dispersion based on proper motions of around σ_l =150 km s^{-1} and σ_b =110 km s^{-1} in Galactic longitude and latitude respectively. In this investigation, we work on one of the least studied bulge low extinction fields, the

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so-called Plaut's window, at (l,b)=(0°,-8°). With $E(B-V) = 0.25 \pm 0.05$ mag, it probes the interesting transition zone between the metal-rich Galactic bulge and the metal-poor halo. This work is based on 43 photographic plates, taken with five different telescopes. The plates were taken in both B and V passbands, have a baseline of 21 years, and some are deep enough ($V_{\rm lim} \sim 22$) to reach below the main-sequence turnoff of the bulge. The plates were digitized with the Yale PDS 2020G microdensitometer. Details of the object detection and centering precision can be found at Vieira et al. (2007). We obtained BV photographic photometry based on 26 photoelectric standards from van den Bergh & Herbst (1974). The proper motions were computed using a central plate overlap method, which provides differential proper motions with respect to a relative reference system. The lack of well measured galaxies made it impossible to provide a reliable zero point for absolute proper motions.

2. RESULTS

After cross-referencing our catalog with 2MASS, we used the infrared photometry to cleanly separate bulge from foreground disk stars. From the J vs. $J-H$ diagram for the Plaut's window, the bulge Red Giant Branch (RGB) can be easily distinguished. The Horizontal Branch (HB) red clump of the bulge can be seen at J ∼13.5 and $J-H$ ∼0.6, and just below it, the RGB bump can be seen at J ∼14 and $J-H$ ∼0.6. Foreground disk main sequence stars are located in the sequence extending upwards ($J \leq 16$) and bluewards ($0.0 \leq J-H \leq 0.45$). Another vertical sequence can be distinguished at $J-H$ ∼0.6 for J <13, the disk red clump of stars, dispersed in magnitude as a result of their large spread in distance and reddening (Zoccali et al. 2003).

From the RGB we selected 482 bulge stars, by using the decontaminated bulge sample of Zoccali et al. (2003) as a template. We also separated a sample of 1851 disk main sequence stars by selecting those with $0.0 \leq J-H \leq 0.45$ and $J \leq 16$. Each population has its own kinematical characteristics, for example, the bulge sample easily stands out from the disk sample, in the $\mu_l \cos b$ distribution, while the disk stars exhibit trends in their proper motions consistent with the projection of the reflex solar motion and even Galactic rotation (for stars fainter than $V \sim 16.7$, i.e. distance ∼ 2 kpc).

The bulge intrinsic proper motion dispersion was calculated from the observed proper motions corrected by the contribution of the estimated errors. We obtained $(\sigma_l, \sigma_b) = (3.39, 2.91) \pm (0.11, 0.09)$ mas yr^{-1}. The observed anisotropy is $\sigma_l/\sigma_b = 1.17 \pm 0.05$. Our result compares fairly well with previous studies, but we obtained one of the highest dispersions of all proper motion investigations of the bulge. This can be easily explained by the closeness of our bulge sample. Using the bulge HB red clump ($K \sim 12.67$) as a distance indicator (Ferraro et al. 2006), we measured a mean distance to our bulge sample of $\sim 6.37^{+0.87}_{-0.77}$ kpc. This means we are looking ∼ 885 pc south of the Galactic plane. With this number we get a velocity dispersion of $(\sigma(v_l), \sigma(v_b)) = (102.30, 87.76) \pm (3.32, 2.85)$ km s^{-1}, which compares well with the prediction by Zhao (1996). We also estimate the rotational velocity at Plaut's location (equations 1 and 2 of Zhao et al. 1996), and we obtain 52.57 ± 8.02 km s^{-1}. This value is in agreement with the bulge rotation curve as measured by other authors (Izumiura et al. 1994).

We also studied the kinematics of the bulge blue horizontal branch stars, which comprise a total of 103 stars, located at $-0.5 < B-V < 0.45$ and $15 < V < 17$ (see Figure 2 of Vieira et al. 2007). Their proper motion distribution looks a bit noisier but very similar to that observed for the bulge RGB stars, which makes a very good case for these stars being bona fide members of the bulge. We obtained $(\sigma_l, \sigma_b) = (4.23, 3.48) \pm (0.30, 0.25)$ mas yr^{-1}, but halo contamination could be responsible for these higher values. Their observed anisotropy is $\sigma_l/\sigma_b = 1.22 \pm 0.12$. This result represents the first kinematic link ever between a metal poor and a metal rich population of the Galactic bulge. Additionally, we studied the metallicity distribution of a subsample of 60 starts from the bulge sample, by using the "hyperbolas" method of Zoccali et al. (2003). A histogram of the metallicities obtained shows a peak at $[M/H] \sim -0.1$ with a somewhat extended metal poor tail, and ∼ 30% of the stars with $[M/H] > 0$, which compares well with previous results (Zoccali et al. 2003). No significant change in the proper motion dispersion is noticed versus $[M/H] > 0$, but since our sample is small and our abundances are based on photometric indices, we do not take this result as a conclusive one in this regard.

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