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THE VERTICAL VELOCITY DISPERSION PROFILE OF THE GALACTIC THICK DISK

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RESUMEN

Presentamos resultados de mediciones de velocidad radial para 770 estrellas gigantes rojas del disco grueso hacia el Polo Galáctico Sur, distribuídas verticalmente desde 0.5 kpc hasta 5 kpc de distancia con respecto al plano Galáctico. Encontramos un pequeño gradiente en la dispersión de velocidad vertical (σ_W) de 3.8±0.8 km s^{-1} kpc^{-1}. Aun mas notable, nuestros valores de σ_W son pequeños comparados con valores de literatura: en el medio del rango de distancia del plano encontramos $\sigma_{W,\mathrm{z=2kpc}}$=30 km s^{-1}. No es posible explicar este pequeño valor de σ_W en términos de contaminación de la muestra por estrellas del disco delgado, y tampoco a través de una errada distribución de metalicidad y las distancias deducidas.

ABSTRACT

We present the results of radial velocity measurements of 770 thick disk red giants toward the South Galactic Pole, vertically distributed from 0.5 kpc to 5 kpc with respect to the Galactic plane. We find a small gradient in the vertical velocity dispersion (σ_W) of 3.8±0.8 km s^{-1} kpc^{-1}. Even more noteworthy, our values of σ_W are small compared to literature values: in the middle of the vertical height range we find $\sigma_{W,\mathrm{z=2kpc}}$=30 km s^{-1}. We found no possible explanation for this small value of σ_W in terms of sample contamination by thin disk stars, nor by wrong assumptions regarding the metallicity distribution and the derived distances.

Key Words: Galaxy: fundamental parameters — Galaxy: kinematics and dynamics

1. INTRODUCTION

We are undertaking a spectroscopic study of nearly 1,200 thick disk red giant stars toward the South Galactic Pole, to analyze the chemical and kinematical vertical structure of the thick disk (Carraro et al. 2005).

The sample is vertically distributed with respect to the Galactic plane, probing the Galactic thick disk with unprecedented detail from 0.5 up to 5 kpc from the Galactic plane. Details regarding target selection in the K *vs.* (J-K) plane using 2MASS photometry and the distance estimation procedure were presented by Girard et al. (2006), who studied the proper motions of the sample from the SPM3 catalog (Girard et al. 2004).

We collected high-resolution Echelle spectra for 770 stars (two thirds of the sample) during two observing seasons in 2005 and 2006 at various instruments. Radial velocities (RVs) were measured through a cross-correlation technique (Tonry & Davis 1979), using as templates three red giant RV standard stars observed in all runs. Using synthetic templates and twilight solar spectra acquired each night we corrected all RVs from systematic errors due to a number of factors, as for example stars not perfectly centered in the slit/fiber and RV variations of the templates. Errors in the measurements are in the range 0.4–1.0 km s^{-1}, they were evaluated quadratically summing up the contribution of all relevant sources (for more details, see Moni Bidin PhD Thesis, in prep.). The comparison with literature RVs for 162 stars with published values reveals an excellent agreement with no systematic trend, and the RV dispersion measured in this subsample is the same as that deduced from the literature RVs.

2. RESULTS

Our results are shown in Figure 1, where the vertical velocity dispersion (σ_W) is plotted as a function of distance z from the Galactic plane. In this plot we conservatively excluded all stars with |W| ≥120 km s^{-1} to avoid ant significant residual contamination of halo stars. Our values are systematically lower when compared to those in the literature. Various values of σ_W for the thick disk have been proposed in the last two decades, varying in the range 40–70 km s^{-1} (see for example Table 1 in Casertano et al. 1990), although recent determinations tend to prefer

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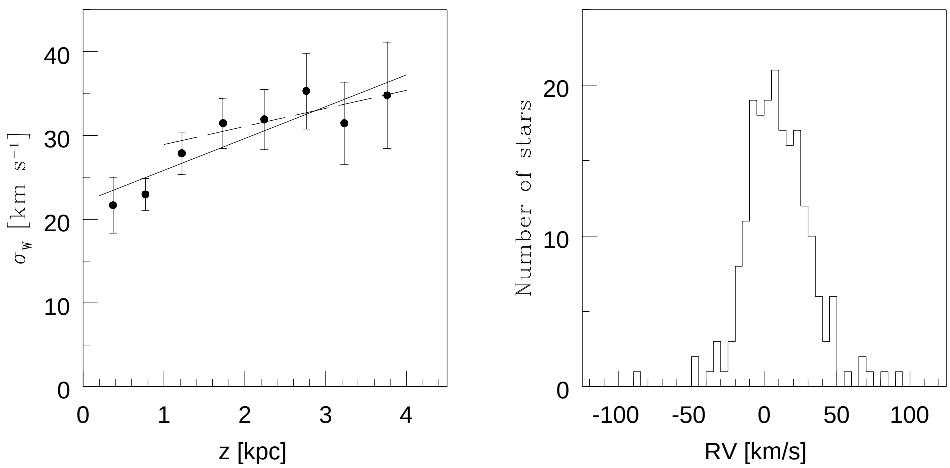

Fig. 1. *Left panel*: Vertical velocity dispersion profile of the sample: The dispersion in W-velocity is plotted as a function of distance from the Galactic plane z. The solid line indicates the least square fit, the dashed line is the fit obtained excluding the first two data points (suspected to be contaminated by thin disk stars). *Right panel*: RV distribution of the 200 stars in the range z=1.5–2.5 kpc.

values in the lower edge of this interval (see for example Soubiran et al. 2003, and the value adopted by Bensby et al. 2003). In contrast, we find a σ_W always smaller than 40 km s^{-1} at all Galactic heights, with $\sigma_{W,\mathrm{z=2kpc}}$=30 km s^{-1}. In the presence of a vertical gradient (see below), the local extrapolated value would be even lower. We note that no effort was made to identify and remove binary systems from the sample, a correction that would further reduce the velocity dispersion.

We find a small vertical gradient of 3.8±0.8 km s^{-1} kpc^{-1}, but it is mainly due to the first two bins, corresponding to the nearest points, where a residual contamination by thin disk red giants can not be excluded. In fact (see Figure 1), after excluding these two first distance bins from the fit, the resulting gradient is much shallower, and within error bars the data are consistent with a flat profile.

We find no plausible source of thin disk contamination that can account for our small values. Thin disk red giants contaminate (if any) only the nearest bins. Dwarfs were efficiently excluded by a cut in magnitude, a (conservative) cut in proper motions (Girard et al. 2006) and a further inspection of all the stellar spectra. Moreover, Girard et al. (2006) showed that in the range z=1–4 kpc the density profile of the sample is well described by a single exponential with a scale height of 783 pc, thus demonstrating that it is dominated by thick disk stars. We found that different assumptions on the metallicity distribution, which can lead to a wrong distance estimate, hardly change the results: Assuming extreme fixed values for the whole sample, we find $\sigma_{W,\mathrm{z=2kpc}}$=31 km s^{-1} for [Fe/H]=$-$0.5 and $\sigma_{W,\mathrm{z=2kpc}}$=27 km s^{-1} for [Fe/H]=$-$1.1.

It is worth noting that our sample selection include stars in a rather wide metallicity interval, but higher metallicities are preferred (see the isocrones in Figure 1 of Girard et al. 2006). Hence, we conclude that either the thick disk is, as a whole, a stellar population kinematically cooler than believed so far, or that there exists some σ_W-metallicity relation, in the sense of the metal-rich component being kinematically cooler. This conclusion was already proposed by Schuster et al. (2006), who argued for the existence of two thick disk components, although their derived σ_W for the kinematically cooler population is still high with respect to ours. Moreover, it is becoming evident that bona-fide thick disk stars extend at least up to solar metallicities (Bensby et al. 2007).

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