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MEASURING THE GALACTIC THICK DISK WITH QUEST-I RR LYRAE STARS

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RESUMEN

En esta contribución presentamos los resultados del sondeo QUEST de estrellas RR Lyrae del disco grueso. El sondeo abarca 480 grados cuadrados, a baja latitud galáctica $|b| < 30$ gds y distancias galactocéntricas entre 7 y 65 kpc; con observaciones multi-época en las bandas VRI, obtenidas con la cámara QUEST-I instalada en el telescopio Schmidt Jürgen Stock ubicado en el Observatorio Astronómico Nacional de Venezuela. A partir de los perfiles de densidad de RR Lyrae observados, derivamos para el disco grueso Galáctico una escala de longitud $h_R = 3.2 \pm 0.4$ kpc, escala de altura $h_Z = 0.94 \pm 0.15$ kpc y normalización $C_{\rm tk} = 15.9 \pm 2.6$ RRab/kpc^3. Adicionalmente encontramos evidencia del *flare* y antitruncamiento del perfil radial del disco grueso Galáctico.

ABSTRACT

In this contribution we present results for the QUEST RR Lyrae Survey of the thick disk. The survey spans 480 sq. deg. at low galactic latitudes $|b| < 30$ deg and galactocentric distances between 7 and 65 kpc, with multi-epoch VRI observations, obtained with the QUEST-I camera and the Jürgen Stock Schmidt telescope located at the National Astronomical Observatory of Venezuela. From the observed RR Lyrae density profiles, we derived a Galactic thick disk scale length $h_R = 3.2 \pm 0.4$ kpc, scale height $h_Z = 0.94 \pm 0.15$ kpc and normalization $C_{\rm tk} = 15.9 \pm 2.6$ RRab/kpc^3. We also find evidence of the thick disk being flared and having an anti-truncated radial profile.

Key Words: Galaxy: disk — Galaxy: stellar content — Galaxy: structure — stars: variables: other

1. INTRODUCTION

The thick disk of the Milky Way is widely recognized as a distinct component, having different kinematics, age and chemistry distinguishable from the thin disk and halo. In external galaxies, recent surveys have found thick disks to be an ubiquitous component, present in $> 90\%$ of disk galaxies. It is therefore crucial for galaxy formation models to reproduce the formation of this component and for observations to provide accurate measurements of Galactic and extra-galactic thick disks' structural, chemical and kinematic parameters to be compared with model predictions. In this contribution we present results for the QUEST RR Lyrae (RRL) Survey of the Galactic Thick Disk.

2. THE QUEST RR LYRAE SURVEY OF THE THICK DISK

The survey spans 480 sq. deg. at low galactic latitudes $|b| < 30$ deg, with multi-epoch observations for 6.45×10^6 objects in three optical photometric bands VRI, obtained with the QUEST-I camera and the Jürgen Stock Schmidt telescope located at the National Astronomical Observatory of Venezuela.

We identified 160 RRab and 51 RRc stars with completeness of 95% and 80% respectively. Distances were derived using individual reddenings computed for each RRab star from observed $V - R$ and $V - I$ colors at minimum light and intrinsinc colors from Guldenschuh et al. (2005) and Kunder et al. (2010). RRL stars from the Vivas et al. (2004) catalogue were included to supplement the survey at high latitudes.

3. MEAN DENSITY PROFILES

We computed the accumulated mean densities $\overline{\rho}_{\rm RR}(\leq R)$ and $\overline{\rho}_{\rm RR}(\leq z)$ of RRLs in the survey volume up to a projected galactocentric radius R and distance perpendicular to the Galactic Plane $|z|$ respectively, according to the following expressions

$$\overline{\rho}_{\rm RR}(\leq R) = V_S^{-1}{}_{(\leq {\rm R})} \iiint\limits_{V_S(\leq R)} \rho(R', z')\ R'dR'dz'd\varphi\,, \quad (1)$$

$$\overline{\rho}_{\rm RR}(\leq |z|) = V_S^{-1}{}_{(\leq |z|)} \iiint\limits_{V_S(\leq |z|)} \rho(R', z')\ R'dR'dz'd\varphi\,, \quad (2)$$

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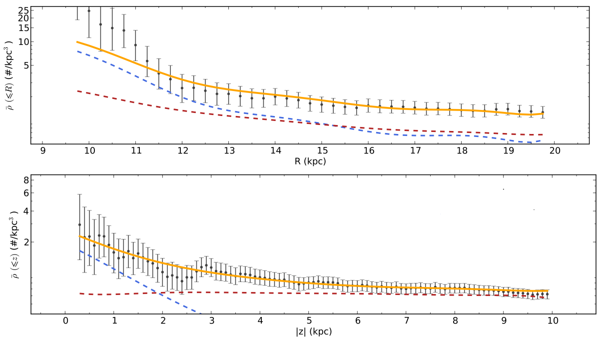

Fig. 1. Mean radial (top) and vertical (bottom) density profiles. The dots with error bars correspond to the observed mean accumulated densities of RRLs. The red, blue and yellow lines correspond respectively to the best-fitting halo, thick disk and total density profiles.

where $\rho(R,z)$ denotes the full density profile corresponding to $\rho(R,z)=\rho_{\rm H}(R,z)+\rho_{\rm TkD}(R,z)$, the sum of the halo and thick disk density profiles. The left-hand side in equations 1 and 2 was computed from the observed distribution of RRLs, while the right-hand side was computed via a Monte Carlo integration of the theoretical halo and thick Disk density profiles. The halo and thick disk profile parameters were obtained from a χ^2 fit of the observed density profiles.

Halo Density Profile We fitted the halo density profile $\rho_{\rm H} = C_{\rm H}(R^2+z^2/q^2)^{n/2}$ to the observed profile for RRLs outside the Galactic Plane ($|z| \geq 6$ kpc), where the thick disk contribution in equations 1 and 2 is expected to be negligible. We obtained a slope $n=-2.9\pm0.2$, flattening $q=0.85\pm0.14$ and local normalization of $C_{\rm H}=3.7\pm0.8$ RRab/kpc^3.

Thick Disk Density Profile Using the parameters obtained for the halo RRL profile in equations 1 and 2, we obtained the best-fitting parameters for the thick disk density profile $\rho_{\rm TkD} = C_{\rm TkD}e^{-(R-R_\odot)/h_R}e^{-|z|/h_Z}$ from the observed radial and vertical density profile for RRLs near the Galactic Plane ($|z| \leq 3$ kpc). The observed and best-fitting halo, thick disk and total density profiles are shown in Figure 1. We obtained a mean scale height $h_Z=(0.94\pm0.15)$ kpc, mean scale length $h_R=(3.2\pm0.4)$ kpc and local normalization of thick disk RRL of $C_{\rm TkD}=(15.9\pm2.6)$ RRab/kpc^3.

The Thick Disk Flare In order to explore the dependence of the scale height h_Z with projected distance R, we fitted the vertical density profile of RRLs in five different distance intervals. The best-fitting scale heights as a function of R are shown in Figure 2,

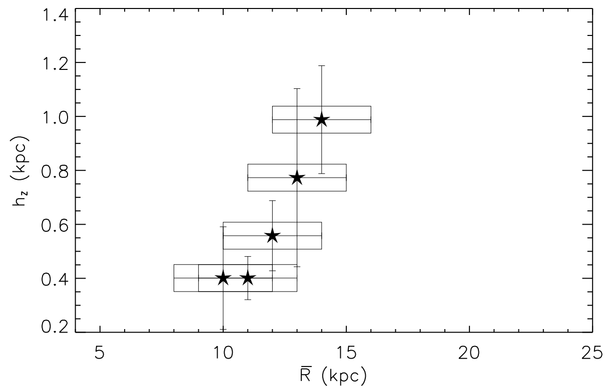

Fig. 2. Thick disk scale height h_Z as a function of R, computed from *in situ* RRLs in five different distance intervals. The horizontal extent of the boxes denotes the width of each radial interval.

which clearly shows h_Z increases monotonically with distance indicating the Galactic thick disk is flared.

Antitruncation of the Thick Disk The radial density profile in Figure 1 (top panel) shows the best-fitting profile underestimates the number of RRLs at distances shorter than ∼11 kpc, when compared to the observations. Further analysis of this radial profile shows there is no apparent RRL overdensity for $R<11$ kpc. This could be interpreted as evidence of the thick disk radial profile being antitruncated or type III (Pohlen et al. 2004). Under this assumption we computed the best-fitting parameters for the antitruncated profile obtaining an inner scale length $h_R=(1.6\pm0.3)$ kpc and brake radius $R_{\rm break}\sim11.5$ kpc.

4. CONCLUSIONS

In this contribution we presented results for the QUEST RRL survey of the Galactic thick disk, the first deep RRL survey conducted at low galactic latitudes to date. The use of RRL at low galactic latitudes covering a large range of radial and vertical distances allowed for the derivation of the thick disk's structural parameters, particularly the scale length, from in situ stars having accurate individual reddenings and distances (errors $<7\%$) and using a tracer that ensures negligible contamination from the Galactic thin disk.

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