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Detect the density profile with LAMOST K giants

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Abstract. The density distribution of the Milky Way halo is detected with 5351 LAMOST DR3 metal poor K giants using a nonparametric method. The nonparametric fitting method is a model independent way to estimate the halo density distribution while to a large extent avoiding the influence of the halo substucture. We show that the K giants density profile can be fitted well by single power law. We found no indication of a break in the power law index. The powerlaw index $n = 5.0^{+0.64}_{-0.64}$. The data show that the stellar halo is flattened at smaller radii, and becomes more spherical farther from the Galactic center. The flattening q(r=15Kpc)is about0.64, q(20Kpc) is about 0.8, q(30Kpc) is about 0.96.

Keywords. Galaxy: halo;Galaxy: structure

1. Sample selection

The LAMOST DR3 K giants (Liu *et al.* 2014) are selected to detect the density profile of the Milky Way halo. The selection criteria include $[Fe/H] < -1$ (eliminating contamination of disk star), $Mr < -0^m.5$(keeping the completeness up to 35Kpc), $K < 14^m.3$ (faint magnitude limit of 2MASS), $E(B-V) > 0.25$ (avoiding unreliable reddening at low latitudes). Finally, there are 5351 K giants satisfy our criteria. Distance of K giants is derived based on the fiducials isochrones (Xue *et al.* 2015).

2. Selection Correction

The selection effect is corrected by comparing CMD between the incomplete spectroscopic sample and a complete photometric sample from 2MASS. The correction is plate by plate. The typical error of stellar density caused by selection correction is $\sigma_\nu/\nu < 0.4$, which can induce 10% deviation on structure parameters. (Liu *et al.* 2017).

3. Number density Map and Nonparametric method

We construct the the tomographic map by calculating medians for all the values of K giants densities ($median(\nu)$) at each R-Z pixel. The relative dispersion of the number density in each (R,Z) pixel is less than 44%. From the map, the isodensity contours looks more like oblate ellipse rather than spherical within 25 kpc.

We probe the the radial number density and flattening profiles of the Galactic stellar halo by fitting the outline of each iso-density surface directly. Thanks to the large sample and wide sky coverage of LAMOST K giants, it is possible to apply for the direct approach to study the structure of the Galaxy with minimal assumptions. We trace the halo density profile along the semi-major axis of an ellipse. The semi-major axis r, and flattening q are determined by fitting the ellipse for each iso-density surface. Because q is very sensitive to

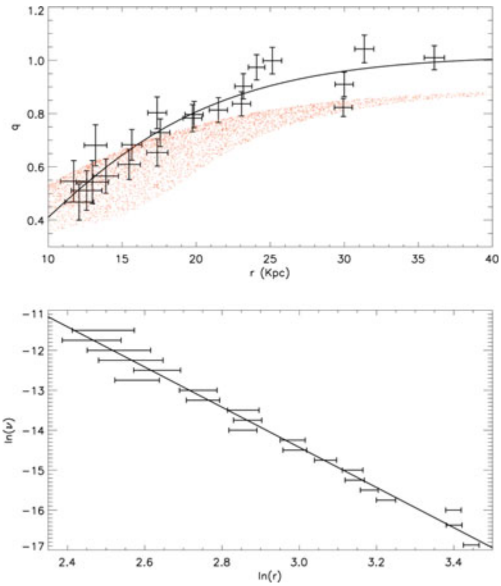

Figure 1. The relations between the shape parameters q and r at different densities respectively. The upper panel shows the q distribution as function of r. The black line shows a rational polynomial fit to the data. The red points shows the results from Xue *et al.* 2015. The lower panel shows the number density as a function of $\ln(r)$. The black line is the power law fit to the data.

the slope of the iso-density surface, and the slope is too steep at low latitude. Therefore, we perform our analysis in r_{GC} vs. $sin\theta$ space.

4. Fitting the data

We divide the K-giant sample into 22 $ln(\nu)$ bins. The binsize is 0.25 in the range of $-16.375 < ln(\nu) < -11.5$, and enlarge to 0.5 in the range of $17.375 < ln(\nu) < -16.375$. In each $(r_{GC}, sin\theta)$ bin, we fit the median value of the distribution of the iso-density surface instead of fitting all data points to lessen the infuence of the outliers. The result is shown in Figure 1. The upper panel shows the relationship between r and q for each $ln(\nu)$ bin. The error bars indicate the errors of fitting derived from MCMC. We empirically fit the r, q relation with the rational polynomial (black line): $q = (p_1 r^2 + p_2 r)/(r^2 + p_3 r + p_4)$, with $p_1 = 0.887, p_2 = 5.15, p_3 = -7.418, p_4 = 315.79$. The red points show result of X15, for comparison. The lower panel of Figure 1 shows the relationship between $ln(\nu)$ and ln(r). We fit the relation with a power law. It can be well fitted by a single power law; with best fit power index at, $n = -5.03 \pm 0.64$.

References

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