

# The Galactic mass distribution from the LAMOST Galactic spectroscopic surveys

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**Abstract.** Using the data from the LAMOST Galactic spectroscopic surveys and some other surveys, we have started a series of work to measure the mass distribution of our Galaxy. As a result of the first-stage, we have constructed the Galactic rotation curve out to 100 kpc and the Galactic escape velocity curve between 5 and 14 kpc. From the two curves, we have built parametrized mass models for our Galaxy, respectively. Both models yield a similar result for the Milky Way's virial mass:  $\sim 0.9 \times 10^{12} M_{\odot}$ .

**Keywords.** Galaxy: fundamental parameters – Galaxy: kinematics and dynamics – dark matter

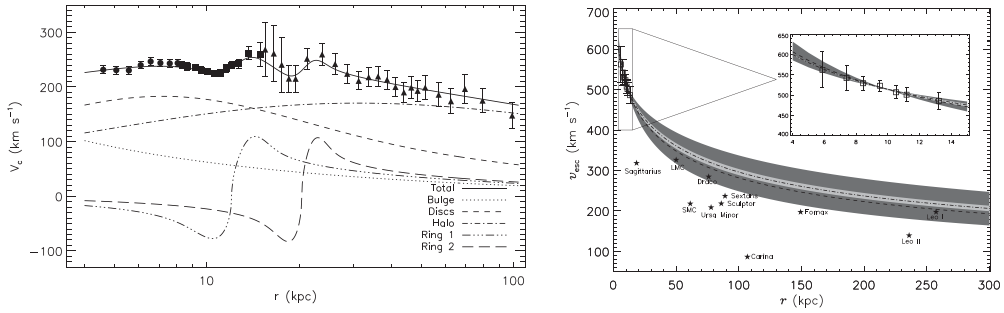
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## 1. The project: the Milky Way mass by LAMOST Survey

Modelling the mass distribution of our Galaxy is one of the fundamental tasks of Galactic astronomy. An accurate measurement of the mass of the Milky Way (MW) is of vital importance for understanding the Galaxy formation and evolution. For example, the number of massive subhalos are highly decided by the virial mass of their host galaxies (e.g. Wang *et al.* 2012). Therefore, the key to understanding the so-called *too big to fail* problem (Boylan-Kolchin *et al.* 2011) for the MW is to accurately estimate the mass of our Galaxy. However, the current measurements of the MW mass are quite uncertain and the results could differ by a factor of 5, from 0.5 to  $2.5 \times 10^{12} M_{\odot}$ .

With the huge stellar spectra database collected by LAMOST (Cui *et al.* 2012), combined with other survey data (e.g. Gaia, SEGUE, APOGEE), we attempt to obtain an accurate measurement for the mass distribution of our Galaxy by a series of studies, including the Galactic rotation curve, the Galactic escape velocity curve, the cold stellar streams and the mass surface density. The Galactic rotation and escape velocity curves could be used to measure the overall mass of the MW, while the mass surface density could provide vital constraint on deriving the mass distribution of different Galactic components (i.e. the bulge, the disc and the dark matter). The study of cold stream could tell the shape information (e.g. spherical, oblate or prolate) of the dark matter. At present, we have finished the work of constructions of the Galactic rotation curve and the escape velocity curve and both studies give a similar result for the MW's virial mass:  $0.9 \times 10^{12} M_{\odot}$  (Huang *et al.* 2016; Huang *et al.* to be submitted). In what follows, we briefly introduce the constructions of the Galactic rotation curve and escape velocity curve, respectively.

First, using  $\sim 6000$  primary red clump giants (PRCGs) in the outer disc selected from the LSS-GAC (Liu *et al.* 2014) and the SDSS-III/APOGEE survey, combined with  $\sim 5700$



**Figure 1.** *Left panel:* Final combined rotation curve of the MW to 100 kpc derived from H I data (dots), PRCGs (squares) and HKGs (triangles). Lines of different styles as labelled in the bottom-right corner of the diagram represent the best-fitting rotation curves contributions from the components of the Milky Way, with the solid line representing the sum of contributions from all the mass components. For details, please see Huang *et al.* (2016). *Right panel:* Galactic escape velocity  $v_{\text{esc}}$  as a function of Galactocentric radius  $r$ . Black boxes represent Galactic escape velocities newly derived from our sample of 527 high velocity halo stars for  $r$  between 5 and 14 kpc. The dashed line and deep gray shade indicate our best-fit model and  $1\sigma$  uncertainty area without a prior on the local circular speed, while the dash-dotted line and the shallow gray shade indicate those with a prior on the local circular speed. The inset in the top-right is to zoom in the region of the newly observed Galactic escape velocity curve for clarity. Black stars represent the total velocities of the named MW classical satellite galaxies. For details, please see Huang *et al.* (to be submitted).

halo K giants (HKGs) selected from the SDSS/SEGUE survey, we have constructed the rotation curve of the MW out to  $\sim 100$  kpc. The newly constructed rotation curve has a generally flat value of  $240 \text{ km s}^{-1}$  within  $r$  of 25 kpc and then decreases steadily to  $150 \text{ km s}^{-1}$  at  $r \sim 100$  kpc (See the *left panel* of Fig. 1).

Secondly, using a sample of 527 high velocity halo stars ( $|v_r| \geq 300 \text{ km s}^{-1}$  and  $[\text{Fe}/\text{H}] < -1$ ) selected from the LAMOST Galactic spectroscopic surveys, we have measured the Galactic escape velocities at  $r$  between 5 and 14 kpc. The Galactic escape velocity at the solar position  $v_{\text{esc}}(R_0)$  is found to  $529 \pm 29 \text{ km s}^{-1}$  (90 per cent confidence). As the *right panel* of Fig. 1 shows, the newly constructed Galactic escape velocity curve decreases steadily from  $562 \text{ km s}^{-1}$  at  $r \sim 5.9$  kpc to  $486 \text{ km s}^{-1}$  at  $r \sim 13.2$  kpc.

Finally, from the constructed rotation and escape velocity curves, we have built parametrized mass models for our Galaxy, respectively. Both models yield a similar results of the virial mass of the MW's dark matter halo of  $0.9 \pm 0.1 \times 10^{12} M_{\odot}$ . The local dark matter density is also found to be  $\sim 0.008 \pm 0.001 M_{\odot} \text{ pc}^{-3}$  from both models.

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