The General Assembly of Galaxy Halos: Structure, Origin and Evolution
Proceedings IAU Symposium No. 317, 2015
A. Bragaglia, M. Arnaboldi, M. Rejkuba & D. Romano, eds.

doi:10.1017/S1743921315008601

The Stellar Age-$T_{\rm eff}$-Kinematical Asymmetry in the Solar Neighborhood from LAMOST

H. J. Tian[1,2], C. Liu[1], J. L. Carlin[3], Y. H. Zhao[1] and X. L. Chen[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China
[2]China Three Gorges University, Yichang, 443002, China; hjtian@lamost.org
[3]Earlham College, 801 National Road West, Richmond, IN 47374, USA

Abstract. With the velocity de-projection technique, we derived the averaged 3 dimensional local velocity distribution using only the line-of-sight velocity for the 200,000 FGK type main-sequence stars from the LAMOST DR1 data. Taking the effective temperature as a proxy for age, we investigate the variation of the velocity distribution as a function of $T_{\rm eff}$ and disk height within $100 < |z| < 500$ pc. Using the mean velocities of the cool stars, we derive the solar motion of $(U_\odot, V_\odot, W_\odot)$=$(9.58 \pm 2.39, 10.52 \pm 1.96, 7.01 \pm 1.67)$ km s^{-1} with respect to the local standard of rest (LSR). Moreover, we find that the stars with $T_{\rm eff} >$ 6000 K show a net asymmetric motion of $\langle U \rangle \sim$ 2 km s^{-1} and $\langle W \rangle \sim$ 3 km s^{-1} compared to the stars with $T_{\rm eff} <$ 6000 K. And their azimuthal velocity increases when $|z|$ increases. The asymmetric motion in the warmer stars is likely because they are too young and not completely relaxed.

Keywords. Galaxy: disk – Galaxy: kinematics and dynamics – solar neighborhood

1. Introduction

The velocity distribution of the stars in the solar neighborhood plays a key role in understanding the global structure, dynamical features, and the evolution of the Milky Way. Although it is often approximated with a multi-dimensional Gaussian profile, the velocity distribution of the stars in the solar neighborhood is actually very complicated. Observations have found many substructures (Zhao *et al.* 2009; Xia *et al.* 2014), which may be associated with the perturbation of the Galactic bar and spiral arms, or belong to old tidal debris of disrupted clusters or dwarf galaxies (Dehnen 2000; Antoja *et al.* 2011). These substructures may shift the mean velocity slightly away from zero by a few km s^{-1}. Many observational evidences have proved the kinematical asymmetry (Carlin *et al.* 2013; Widrow *et al.* 2012; etc.).

The velocity distribution can be characterized by the velocity ellipsoid, which reflects the mass distribution and evolution of the Milky Way, assuming that most of the detected stars are in equilibrium. Many works have found that the age of stars is correlated with the velocity distribution. Specifically, older stars show larger velocity dispersion, and vice versa (Parenago 1950). This is usually thought to be because scattering of the disk stars increases over time. The age–velocity dispersion relation (AVR) reflects the evolution history of the Galactic disk.

2. Data and Results

LAMOST FGK-type Stars. The LAMOST Survey has delivered the first data release (DR1), which contains 1,085,404 stellar spectra with estimated stellar atmospheric parameters as well as line-of-sight velocities. The distances to stars are determined with uncertainty of ∼20% from isochrone fitting by Carlin *et al.* (2015). With the criteria

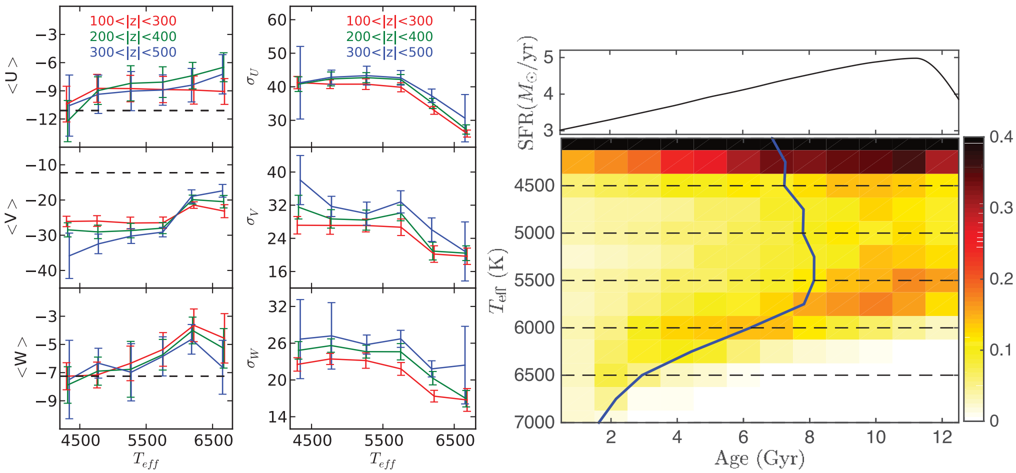

Figure 1. The left and middle panels present the variation of the mean velocities and ellipsoids as a function of $T_{\rm eff}$ in three disk heights, the right panel shows the age-$T_{\rm eff}$ relation.

provided by Tian *et al.* (2015, hereafter T15), we selected a total of 209,316 FGK type main-sequence stars to investigate the kinematics of the solar neighborhood.

The Mean Velocities and Ellipsoids. The LAMOST FGK sample spans a large area of the sky, which allows us to use the de-projection technique described in T15 to measure the 3 dimensional velocity and its ellipsoid from only the one dimensional line-of-sight velocities. The left and middle panels of Fig. 1 demonstrate the correlations of the three velocity and the three velocity ellipsoid components with $T_{\rm eff}$ in three slices of $|z|$. The most obvious feature is that the three mean velocities and ellipsoids are all correlated with $T_{\rm eff}$ for all $|z|$ bins. The warmer stars with $T_{\rm eff} > 6000$ K show a net asymmetric motion. The velocity dispersions show clear trends either along $T_{\rm eff}$ or $|z|$. All three velocity dispersions show an abrupt drop at around $T_{\rm eff} \sim 6000$ K in all $|z|$ bins. Using the cool and old stars (probably in equilibrium), we derived the solar motion of ($U_\odot$, $V_\odot$, $W_\odot$)=(9.58 ± 2.39, 10.52 ± 1.96, 7.01 ± 1.67) km s^{-1} with respect to the LSR.

The Age-$T_{\rm eff}$ Relation. Given a star formation history and a star formation rate (the right-top sub-plot in Fig. 1), we can set up the stellar distribution in age vs. $T_{\rm eff}$ plane using synthetic isochrones and an initial mass function, to reveal the reason why the kinematic features for the stars with $T_{\rm eff} > 6000$ K are significantly different from those for the cooler stars. The blue thick line shows the mean age at different $T_{\rm eff}$. It shows that for the stars with 6000 $< T_{\rm eff} <$ 7000 K, the mean age is only 4 Gyr. The $T_{\rm eff}$ of the abrupt change in age is perfectly consistent with that of the sudden change in the mean velocity and velocity dispersions. The stars with $T_{\rm eff} > 6000$ K are too young, it is the probable reason why those stars show significant bulk motion in all three orientations.

References

Antoja, T., Figueras, F., Romero-Gómez., M. *et al.* 2011, *MNRAS*, 418, 1423
Carlin, J. L., DeLaunay, J., Newberg, H. J. *et al.* 2013, *ApJL*, 777, 5
Carlin, J. L., Liu, C., Newberg, H. J. *et al.*, 2015, *AJ*, 150, 4
Dehnen, W. 2000, *AJ*, 119, 800
Tian, H. J., Liu, C. *et al.* 2015, *ApJ*, 809, 145
Widrow, L. M., Gardner, S., Yanny, B. *et al.* 2012, *ApJL*, 750, 41
Xia, Q. R, Liu, C., Mao, S. *et al.* 2014, *MNRAS*, 447, 2367
Zhao, J. K., Zhao, G., & Chen, Y. Q., 2009, *ApJL*, 692, 113