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Local Kinematics and the Local Standard of Rest with *Gaia* Radial Velocity Survey

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1. INTRODUCTION

It is known that stars in the galactic disk form from gas clouds orbiting the galactic center. Thus, younger stars are more likely to be on approximately closed orbits like the gas. On the other hand, older stars follow more eccentric orbits with higher tangential velocities. Since hotter stars have a shorter lifetime than colder ones, we assume that they are in average younger. The local standard of rest (LSR) follows the mean motion of the disk material in the solar neighborhood (Shu 1982), and there are different methods for its determination. i) Strömgrens method involving finding a relation between mean velocity and velocity dispersion for different stellar populations, and extrapolating to zero velocity dispersion (e.g. Ding et al. (2018)), ii) determine nearly-circular orbits from 6D phase-space data of the stars (e.g. Francis & Anderson (2018)), iii) specifically observing young OB stars (e.g. Bobylev & Bajkova (2018)), iv) fitting the data to a model of the phase-space distribution function.
However, since the amount of data provided by the *Gaia* mission (Gaia Collaboration et al. 2016) is significantly larger than previous data sets, we used a much simpler method. Since we are interested in nearly-circular orbits of young stars, we look at the velocities of high temperature stars.

2. DATA SELECTION & DATA TRANSFORMATION

Our analysis is based on data from the *Gaia* DR2 radial velocity survey[1], closer than 100pc away from our Sun. Furthermore, all stars with either $\frac{\sigma_{\alpha*}}{\alpha^*}, \frac{\sigma_\delta}{\delta}$ or $\frac{\sigma_{\bar\omega}}{\bar\omega}$ larger than 0.1, and $\sigma_{v_{rad}} \leq |5|$ km s^{-1} are neglected.
To obtain the velocities μ_{α^*}, μ_δ and v_{rad} are transformed to Cartesian coordinates using

$$\vec{v}_{Equat} = \begin{pmatrix} v_x \\ v_y \\ v_z \end{pmatrix} = \begin{pmatrix} rv\cos(\alpha)\cos(\delta) - dk\mu_{\alpha*}\cos(\alpha)\sin(\delta) - dk\mu_\delta\sin(\alpha) \\ rv\sin(\alpha)\cos(\delta) - dk\mu_\delta\sin(\alpha)\sin(\delta) + dk\mu_{\alpha*}\cos(\alpha) \\ rv\sin(\delta) + dk\mu_\delta\cos(\delta) \end{pmatrix}, \tag{1}$$

in km s^{-1} where d is the distance, and k is introduced to transform au yr^{-1} to km s^{-1}. These velocities in Equatorial coordinates are transformed to Galactic coordinates by multiplying with a rotation matrix

$$A'_G = R_z(-l_\Omega)R_x(90^\circ - \delta_G)R_z(\alpha_G + 90^\circ). \tag{2}$$

given in equations 3.60 & 3.61 of the *Gaia* DR2 documentation (Gaia DR2 Documentation 2018).

3. LOCAL KINEMATICS

Stars similar to our Sun are confined to a thin disk, orbiting the center of the Galaxy (Keel 2007). Because of gravitational potential of all objects in the Milky Way, stars cross the disk in an oscillating motion as well as they

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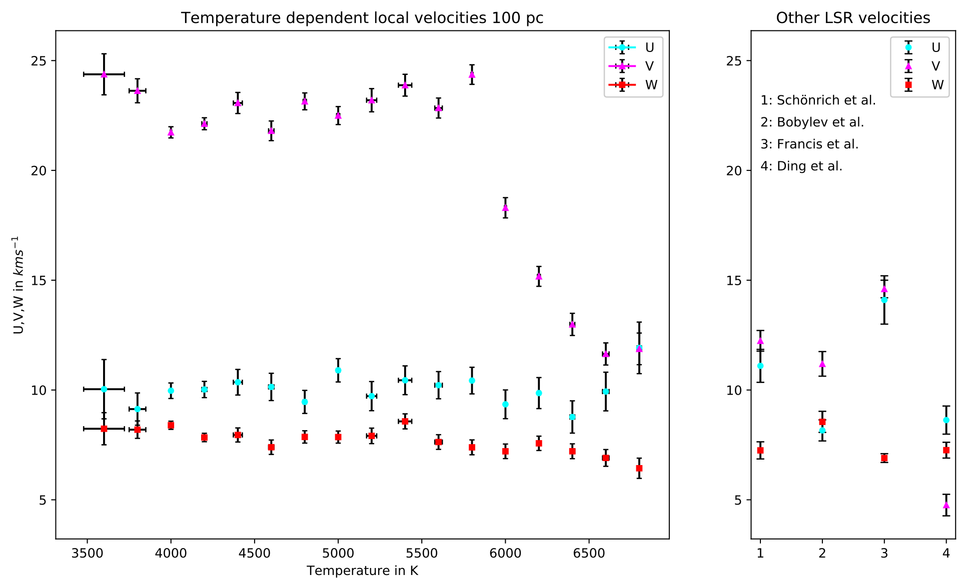
[1] http://cdn.gea.esac.esa.int/Gaia/gdr2/gaia_source_with_rv/csv/

do in radial direction. Since all stars are assumed to follow such motions, this should result in a statistically steady state (Tayler 1993). The stars from the dataset were grouped by temperature in steps of $200K$, where groups with less than 300 objects were neglected. Then, the mean values for each component of (U, V, W) were calculated for each group. The temperature-dependent behavior can be found in figure 3.



4. LOCAL STANDARD OF REST

As described in section 1, we look at the velocities of high temperature stars. The highest temperature with sufficient data is 6800K with $(U, V, W)_{\odot} = (11.92 \pm 1.17, 11.87 \pm 0.72, 6.44 \pm 0.46)\,\mathrm{km\ s^{-1}}$.
Compared to other results, e.g. (Schönrich et al. 2009), (Bobylev & Bajkova 2018), (Francis & Anderson 2018) or (Ding et al. 2018), one can see that our values are within uncertainties with *Schönrich et al.* which probably enjoys the highest acceptance. However, as one can see there is not really a consensus for these velocities and it is not clear how the different results should be interpreted.

5. CONCLUSION

It was shown that the motion of nearby stars is almost independent of temperature for stars with T$\leq$ 5800K. At this temperature, $V_{\odot}$ drops significantly. Since there is not enough data on the high-temperature area, it is not possible to make predictions how velocities change there.
As shown in section 4, recent results of the LSR are not consistent. Therefore, it is not clear if we really have found a simple but robust way to determine the LSR. It would be interesting to test our method again, once there is more data accessible for stars with temperatures above 6800K.

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