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Thick disk kinematics from RAVE and the solar motion

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Abstract. We present a method to derive kinematic parameters for the Galactic thick disk based on stellar radial velocity data alone, without previous knowledge of distances. The prospects and limitations of this method are then explored with the aid of photometric distances. We introduce selection criteria in order to clean the observed radial velocities from the Galactic differential rotation and to take into account the partial sky coverage of RAVE. We deduce the components of the Solar motion relative to the Local Standard of Rest (LSR) in the radial and vertical directions as well as the components of the velocity dispersion tensor. The results extend the analysis already started on the velocity distribution function of the thin and thick disk with RAVE data.

1. METHOD AND DATASET

We consider all the stars in the RAVE catalogue [1] for which the Galactic contribution to the radial velocity component, $\delta v_r^{[G]}$, expected to be much smaller than the error, Δv_r, of the radial velocity itself for each star. For this sample (in Fig. 1) the Galactic effect in the radial velocity component, $\delta v_r^{[G]}$, can be approximated as:

$$\delta v_r^{[G]} = \delta v_r^{[G]} (r_{\mathrm{hel}}, l, b, \|\mathbf{v}_{\mathrm{m}}\|) \cong \delta v_r^{[G]} (l, b, \|\mathbf{v}_{\mathrm{m}}\|) \tag{1}$$

where r_{hel}, the unknown or photometrically determined heliocentric distance [3], (l, b) are the Galactic coordinates for the star and $\|\mathbf{v}_{\mathrm{m}}\|$ is an optimized mean stream velocity for the sample of data selected as explained in our forthcoming paper (Pasetto et al. 2010). We then proceed by using the Singular Value Decomposition technique to solve for the mean velocity of the sample and then by computing the central moment of the distribution up to 4th order. The thick disk component is disentangled from the mixture of thin and thick disk stars as in [2] but with an iterative procedure.

2. RESULTS

2.1 Solar motion relative to the Local Standard of Rest

We compute the Solar motion relative to the LSR along the radial and vertical direction:

$$\{v_R, v_z\}_\odot = (10.41, 7.00) \pm (0.11, 0.19)\,\mathrm{km} \cdot \mathrm{s}^{-1} \tag{2}$$

The values are obtained under the assumption that the sky coverage is sufficient for the cross-terms of the projection operator on the velocity vector to average to zero, i.e., we select a kinematically unbiased sample of stars where the directional vector to each star and the velocity vector are uncorrelated. The

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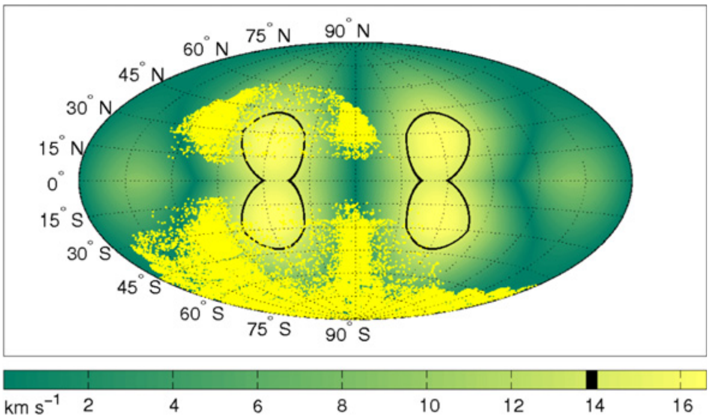

Figure 1. Projected star distribution (yellow points) on the sky for the RAVE data adopted for the analysis. We excluded data inside the black contour regions derived from equation 1.

azimuthal value cannot be disentangled from the lag of the thick disk component. We tested this assumption with the help of the Padova Hertzsprung-Russel Diagram Galactic Software Telescope combined with a kinematic model and a potential-density model well tuned on the Galaxy (e.g., [4], Pasetto, PhD thesis, 2005). The study of the thick disk stellar population (i.e., its star formation history and initial mass function) is deferred to a forthcoming paper.

2.2 Velocity dispersion tensor (without distances)

Our approach permits us to compute the velocity dispersion tensor without the use of distances. For the first time, we find in the RAVE data a tilt of 4.9±1.2 deg in the thick disk data alone. We derive for the diagonal elements of the velocity dispersion tensor:

$$\left(\sigma_{\mathrm{RR}}, \sigma_{\phi\phi}, \sigma_{\mathrm{zz}}\right)_{\odot} = (59.2, 49.6, 35.5) \pm (4.2, 5.3, 3.8)\,\mathrm{km} \cdot \mathrm{s}^{-1} \tag{3}$$

2.3 Velocity dispersion tensor (with distances)

Finally, we use a subsample of the RAVE dataset with photometrically determined distances ([2]) to check the validity of the method and to extend our analysis. We are able to disentangle the thick disk velocity dispersion tensor of stars within and outside the Sun's position in the Galactic plane:

$$\left(\sigma_{\mathrm{RR}}, \sigma_{\phi\phi}, \sigma_{\mathrm{zz}}\right)(R < R_{\odot}) = (61.1, 48.7, 37.2) \pm (16.1, 7.6, 12.7)\,\mathrm{km} \cdot \mathrm{s}^{-1} \tag{4}$$

$$\left(\sigma_{\mathrm{RR}}, \sigma_{\phi\phi}, \sigma_{\mathrm{zz}}\right)(R \geq R_{\odot}) = (57.1, 48.4, 35.3) \pm (3.2, 5.7, 3.9)\,\mathrm{km} \cdot \mathrm{s}^{-1} \tag{5}$$

RAVE is able for the first time to indicate the possibility of a small decreasing trend in the velocity ellipsoid from the inner to the outer part of the galaxy and shows the need to forgo the classical isothermal anisotropic thick disk picture.

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