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ON THE KINEMATICS OF STARS FROM THE SOLAR NEIGHBOURHOOD CASE OF THE TWO DISC COMPONENTS

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Abstract. The kinematics of stars from the Solar neighbourhood which belong to either of the two discs – thin or thick – is modelled following particular Gaussian distributions of their random velocities. As the mean motion in both cases rotation (circular motion of the centroid) is admitted. Assuming a given value for the galactocentric speed of Local Standard of Rest (LSR) it is possible to model the same samples in their motion with respect to LSR. Here for each sample (each of the discs) one has five parameters: three velocity dispersions, rotation speed and LSR speed. Varying these parameters we find the fractions of stars, members of either disc, which occupy a given volume in the velocity subspace centred on the LSR. In the case of the thin disc we find that almost all stars are within a sphere centred on LSR with radius equal to 120 km s^{-1} and this result is practically independent of the value assumed for the galactocentric speed of LSR. In the case of the thick disc almost all stars are within a sphere centred on LSR with radius equal to 250 km s^{-1}, but this result appears to be slightly dependent of the value assumed for the galactocentric speed of LSR.

1. INTRODUCTION

In the case of stars from the Solar neighbourhood very often the mere knowledge of the speed of a star can be indicative for the purpose of the kinematical membership of this star. Recently we studied the case of stars supposed to belong to the Galactic halo (Ninković et al. 2012 Paper I). That time we indicated the limits in the velocity subspace which contain given fractions of halo stars. However, any study of the halo is incomplete if the Galactic disc is not taken into account. Therefore, here we apply the same procedure for stars of the Galactic disc.

2. APPROACH

We assume that in general the Galactic disc, at least, at the galactocentric position of the Sun, can be split in two components known as thin disc and thick disc. The speed of a star taken here into account is that with respect to the local standard of rest (LSR).

As described in Paper I, for a given component (sample) we have five parameters: velocity dispersions along the standard axes (x-axis, velocity component U towards Galactic centre; y-axis, velocity component V in sense of Galactic rotation and z-axis, velocity component W towards north Galactic pole), centroid velocity (rotation speed) and galactocentric speed of LSR. Here we have two artificial star samples representing the two disc components. Every sample star is assigned component values U, V, W of its random velocity. Its speed with respect to LSR is calculated by using the following formula:

$$v = \sqrt{U^2 + (u + V - v_0)^2 + W^2}\ . \tag{1}$$

Here v is the speed of the star with respect to LSR, u is the rotation speed and v_0 is the galactocentric speed of LSR. The value of v is further used in determining to which part of the velocity subspace the star belongs. Such values are referred to as interval limits in Table 1. In this table under each interval the corresponding fraction of stars is given.

For the thin disc we assume only one set of velocity dispersions: 34, 22, 17 (along the three axes, respectively, in km s^{-1}, Fig. 1) following the result of Vidojević & Ninković (2009). The rotation speed is assumed to be always by 10 km s^{-1} slower than the galactocentric speed of LSR. In the case of the thick disc taking into account the existing evidence (e.g. Alcobé and Cubarsí 2005) we assume for the velocity dispersions values approximately twice as those for the thin disc; the rotation speed is assumed to be always by 60 km s^{-1} slower than the galactocentric speed of LSR (Fig. 2).

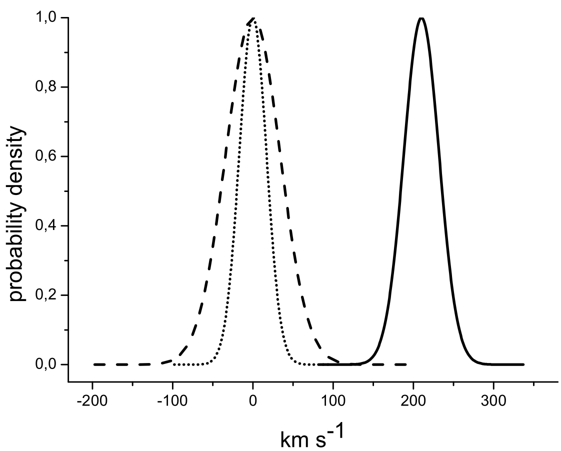

Figure 1: Gaussian velocity distribution for thin-disc stars: dashed curve x axis (centred on 0 km s^{-1}, dispersion 34 km s^{-1}); solid curve y axis (centred on 210 km s^{-1}, dispersion 22 km s^{-1}); dotted curve z axis (centred on 0 km s^{-1}, dispersion 17 km s^{-1}).

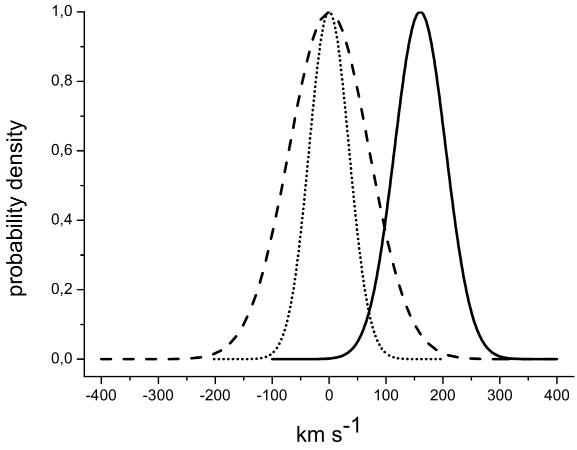

Figure 2: Gaussian velocity distribution for thick-disc stars: dashed curve x axis (centred on 0 km s^{-1}, dispersion 70 km s^{-1}); solid curve y axis (centred on 160 km s^{-1}, dispersion 45 km s^{-1}); dotted curve z axis (centred on 0 km s^{-1}, dispersion 35 km s^{-1}).

3. RESULTS

The speed of LSR is varied between 190 and 250 km s^{-1} (step equal to 30 km s^{-1}). For each particular value we calculate for every sample star its speed with respect to LSR v (formula 1) and determine the fractions of sample stars within an inner sphere centred on LSR, beyond an outer concentric sphere and between the two spheres. The radius of the inner sphere is varied to include three different values: 80, 100 and 120 (km s^{-1}), that of the outer sphere is always the same: 250 km s^{-1}. What we obtain is that for the thin disc practically all stars are within 120 km s^{-1} from LSR and this is practically independent of the assumed value for the galactocentric speed of LSR. In the case of the 80 km s^{-1} sphere the obtained fractions indicate a dependence on the assumed speed of LSR, if 190 km s^{-1} is used, the fraction is substantially lower than in the cases of the other two values for which the corresponding fractions are rather similar. The randomiser has a very weak influence.

In the case of the thick disc the situation is similar, but this time the results corresponding to the LSR speed of 250 km s^{-1} show a somewhat more significant deviation yielding lower fractions. Clearly, as in the case of the thin disc, there is a speed value (with respect to LSR) beyond which the fraction of stars is practically zero. This time it is 250 km s^{-1}. Within the speed value playing the analogous role in the case of the thin disc (120 km s^{-1}) a dependence of the fraction of thick-disc stars on the value assumed for the galactocentric speed of LSR is manifested. In particular, if 250 km s^{-1} is assumed, we have 60%, but as this value decreases, the fraction within 120 km s^{-1} increases, to attain about 75%.

In a more complete way the results are given in Table 1. The columns contain: first – the disc component; second – the galactocentric speed of LSR; the other ones – speed limits and corresponding fractions of stars.

Table 1. The fractions of stars for both discs depending on LSR speed.

Comp.	LSR speed [km s^{-1}]	Speed km s^{-1}	Frac. %	Speed km s^{-1}	Frac. %	Speed km s^{-1}	Frac. %
THIN DISC	220	[0,80]	76.6	(80,250)	23.4	[250,∞)	0
		[0,100]	92.2	(100,250)	7.8	[250,∞)	0
		[0,120]	98.8	(120,250)	1.2	[250,∞)	0
	190	[0,80]	61.6	(80,250)	38.4	[250,∞)	0
		[0,100]	81.6	(100,250)	18.4	[250,∞)	0
		[0,120]	96.0	(120,250)	4.0	[250,∞)	0
THICK DISC	220	[0,80]	37.2	(80,250)	62.8	[250,∞)	0
		[0,100]	55.2	(100,250)	44.8	[250,∞)	0
		[0,120]	73.6	(120,250)	26.4	[250,∞)	0
	250	[0,80]	24.4	(80,250)	75.4	[250,∞)	0.2
		[0,100]	41.2	(100,250)	58.8	[250,∞)	0
		[0,120]	59.2	(120,250)	40.6	[250,∞)	0.2

4. CONCLUSIONS

In studying the distribution of stars from the Solar neighbourhood we find some limiting values of speed with respect to LSR. In particular, we find that within a sphere centred on LSR with radius equal to 120 km s^{-1} practically all stars of the thin disc are contained and also about two thirds of stars belonging to the thick disc. The fraction of thick-disc stars shows a dependence on the value assumed for the LSR speed with respect to the Galactic centre. This can be expected with regard that the velocity dispersion for the thick disc exceeds that for the thin disc. So the fraction of two thirds corresponds to the value of 220 km s^{-1} for LSR around the centre of the Milky Way. Taking into account the results of Paper I, that beyond the sphere of 250 km s^{-1} centred on LSR we have approximately half halo stars from the Solar neighbourhood, we can say that these very-high velocity are dominated by the halo, unlike those within 120 km s^{-1} where the percentage of halo stars is very low (usually under 10%).

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