Kinematics of the local disc from the RAVE survey and Gaia-TGAS

Annie C. Robin[1], Olivier Bienaymé[2], José G. Fernández-Trincado[1], Céline Reylé[1]

1. Institut Utinam, Besançon
2. Observatoire Astronomique de Strasbourg

Abstract: We study the kinematics of the thin and thick discs using the Besançon population synthesis model together with **RAVE** DR4 and **Gaia** first data release (**TGAS**). We account for the asymmetric drift computed from fitting a Stäckel potential to orbits Bienaymé et al (2015). We show that this model is able to reproduce the kinematics of the local discs in great detail. It reproduces well the velocity distribution in a wide solar neighbourhood. The $U_\odot$ and $W_\odot$ components of the Solar motion agree well with previous studies. However we find a $V_\odot$ of 1 km/s, essentially due to the inclusion of the variation of the asymmetric drift with distance to the plane. The TGAS-RAVE sample allows to constrain the thin and thick disc dynamical evolution, as well as determining the Solar motion.

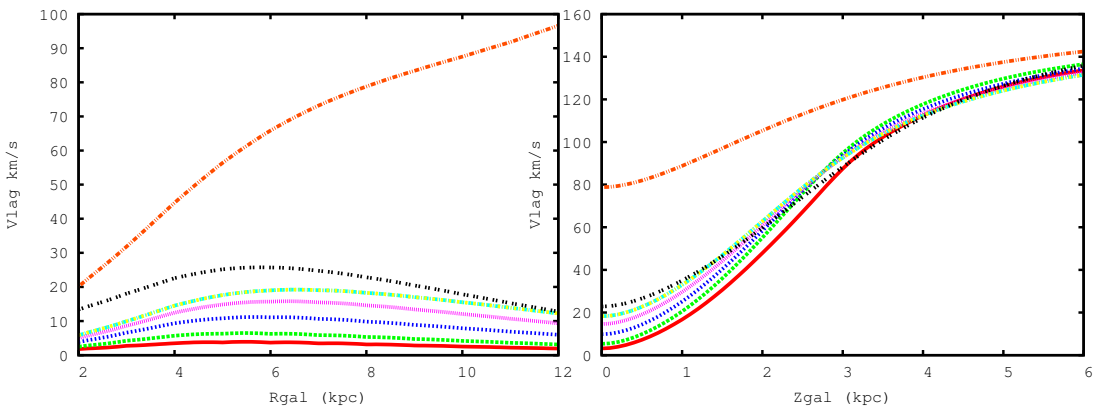


*Fig. 1: **Asymmetric drift** computed from the **Stäckel approximation of the BGM potential** for subcomponents 2 to 7 (thin disc, with ages increasing in solid red, long-dashed green, short-dashed blue, dotted magenta, dashed yellow-cyan), and for the young (dotted-dashed black) and old (dotted-dotted- dashed red) thick discs. Left panel: as a function of R_{gal} for z_{gal} =0; Right panel: as a function of z_{gal} for R = $R_\odot$.*

The **asymmetric drift** (***Fig. 1***) is computed for each disc sub-component of the Besançon Galaxy Model (BGM) by fitting a **Stäckel potential** to orbits in the gravitational potential defined by BGM mass distribution (Bienaymé et al. 2015).

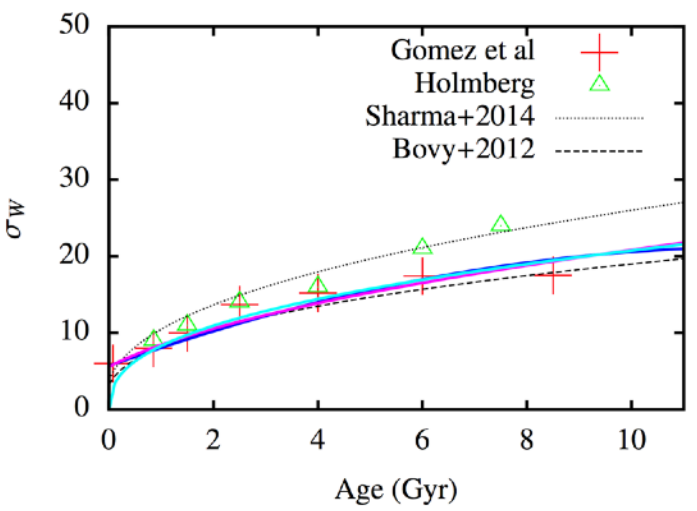
After simulating RAVE-TGAS fields with BGM, we compute radial velocity distributions **in bins of temperature and metallicity**, and we adjust model parameters using an ABC-MCMC algorithm. The parameters are indicated in table 1, mainly : **Solar motion**, **vertex deviation, age-velocity dispersion of the thin disc, velocity ellipsoids of the thick disc, and gradients of velocity dispersion**.

Table 1 shows results, assuming an age-velocity dispersion as a 3rd order polynomial (A, B, C). Similar results are obtained with various mathematical function for this relation (shown in ***fig. 2***).

*Table 1: Results of the **MCMC fit of RAVE+TGAS** radial velocity distribution and proper motions, assuming two rotation curves (Caldwell & Striker 1981 or Sofue 2015)*

Parameter	Caldwell	Sofue
Solar motion		
$U_\odot$	12.75 ± 1.26	11.88± 1.38
$V_\odot$	0.93 ± 0.30	0.91± 0.26
$W_\odot$	7.10 ± 0.16	7.07± 0.16
Vertex deviation		
VD_a	-0.0439 ± 0.0375	-0.0618± 0.0218
VD_b	-0.0144 ± 0.0122	-0.0048± 0.0108
Thin disc		
A	5.69 ± 0.37	5.69± 0.41
B	2.48 ± 0.30	2.33± 0.28
C	-0.0966 ± 0.0404	-0.0774± 0.0362
σ_V/σ_U	0.57 ± 0.03	0.58± 0.03
σ_W/σ_U	0.46 ± 0.03	0.46± 0.02
h_{σ_U}	13176. ± 6908.	9534.± 3982.
h_{σ_W}	15919. ± 8609.	10414.± 6299.
Thick disc		
σ_U	40.02 ± 1.74	41.58± 1.51
σ_V	31.86 ± 1.55	30.95± 1.50
σ_W	27.89 ± 1.26	27.02± 1.00
Old thick disc		
σ_U	75.64 ± 8.58	79.64± 7.96
σ_V	55.41 ± 8.74	57.55± 8.51
σ_W	66.43 ± 3.95	62.15± 6.62
Lr	-5384. ± 38.	-5378.± 155.
BIC	10861. ± 76.	10851.± 161.

*Fig. 2: **Evolution of the vertical velocity dispersion of the thin disc with age**. The solid lines show the best fit solutions for the 3 different formulae (fit 1: blue, 2: magenta, 3: cyan, see text), while the symbols indicate the Gómez et al. (1997) values from Hipparcos (red plus) and Holmberg et al. (2009) (green triangles). Black dotted line is the relation from Sharma et al. (2014) while black dashed line is the one from Bovy et al. (2012).*



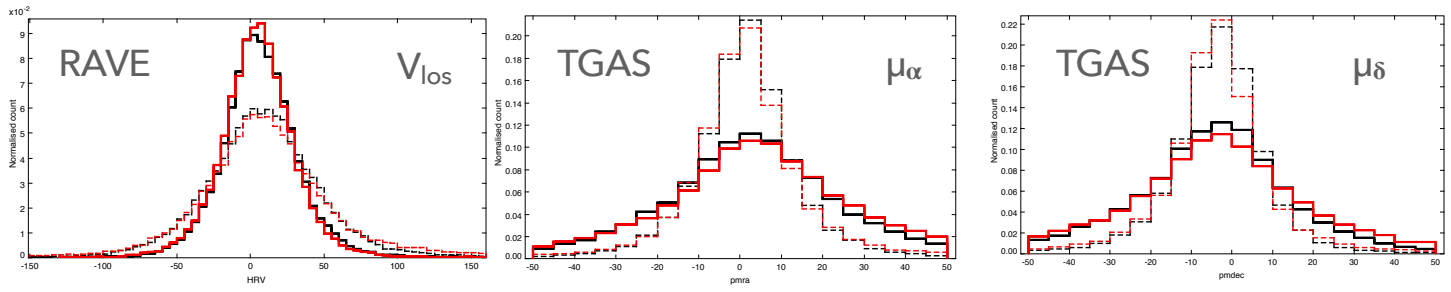


*Fig. 3: **Histograms of RAVE** (Kordopatis et al, 2014) **radial velocity** distributions and **TGAS** (Gaia collaboration, Brown et al, 2016) **proper motions for hot stars** defined as Teff>5200K (solid lines) and **cool stars** (dashed lines) defined as Teff<5200K. **Data**: black lines; Best fit **model**: red lines.*

Conclusions:

1) When taking into account the asymmetric drift variations with R_{gal} for z_{gal} , the **Solar motion is found to be ($U_\odot$=13 km/s, $V_\odot$=1 km/s, $W_\odot$=7 km/s)**, while using the simple formula $V_\odot$ was found significantly larger. Our new value is in good agreement with Golubov et al (2013) who found $V_\odot$=3km/s from RAVE iDR4.

2) The overall fit of this **new dynamical and kinematical model** reproduces very well the radial velocity distributions from RAVE, as well as the proper motions from Gaia-TGAS in a wide solar neighbourhoud and specifically **for different metallicity bins and temperature bins** (***fig. 3***).

For more details: Robin, Bienaymé, Fernández-Trincado, Reylé, accepted in A&A, astroph:1704.06274

References :

Bienaymé, O., Robin, A. C., & Famaey, B. 2015, A&A, 581, A123
Bovy, J., Allende Prieto, C., Beers, T. C., et al. 2012, ApJ, 759, 131
Caldwell, J. A. R. & Ostriker, J. P. 1981, ApJ, 251, 61
Gaia Collaboration, Brown, A. G. A., Vallenari, A., et al. 2016, A&A, 595, A2
Gómez, A. E., et al. 1997, in ESA Special Publication, Vol. 402, Hipparcos - Venice '97, ed. R. M. Bonnet et al, 621–624
Golubov, O., Just, A., Bienaymé, O., et al. 2013, A&A, 557, A9
Holmberg, J., Nordström, B., & Andersen, J. 2009, A&A, 501, 941
Kordopatis, G., Gilmore, G., Steinmetz, M., et al. 2013, AJ, 146, 134
Sharma, S., Bland-Hawthorn, J., Binney, J., et al. 2014, ApJ, 793, 51
Sofue, Y. 2015, PASJ, 67, 75