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How far away and how old are these stars?

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Abstract. RAVE is the spectroscopic survey with the largest overlap with TGAS (around 200 000 stars). Since RAVE's fourth data release, it has contained distance estimates based on a Bayesian estimation scheme. Here we compare these estimates to TGAS's parallaxes, to determine the strengths and weaknesses of each. We also combine the two datasets together to find more precise distance estimates for all these stars.

Keywords. surveys, Galaxy: structure, Galaxy: kinematics and dynamics, methods: statistical

1. Introduction

The RAVE survey (Kunder *et al.* 2017) is a spectroscopic survey that has taken spectra for ∼500 000 stars. This provides the radial velocity for all of these stars, along with structural parameters of the stars such as their effective temperature, $T_{\rm eff}$, surface gravities, $\log g$, and metallicities $[M/H]$. These can be used, in combination with photometry (in our case from 2MASS: Skrutskie *et al.* 2006) to derive the distances to stars, and since RAVE's fourth data release these have been provided by the Bayesian method introduced by Burnett & Binney (2010). This method inevitably gives insight on other stellar properties (such as age) while finding distance estimates.

The arrival of parallaxes from the Tycho-Gaia astrometric solution (Lindegren *et al.* 2016) means that we now have parallaxes estimates for ∼ 200 000 of these stars. In this note, we compare the parallaxes found by TGAS and those found from the RAVE spectrophotometric pipeline. We then incorporate the TGAS parallaxes into the Bayesian distance estimation. This provides us with distance (or parallax) estimates that are significantly smaller than those using either alone.

2. Results

Figure 1 shows the median difference between the TGAS parallaxes ϖ_T and those from RAVE ϖ_{Sp} for the same stars, binned by position on sky (left panel). There is a clear problem region (running to the ecliptic pole) corresponding to $\varpi_T > \varpi_{Sp}$. This seems to be a problem with the TGAS parallaxes (related to the scanning law), and was also seen by Arenou *et al.* (2017). The right-hand panel of figure 1 shows the median value of the parallax difference divided by uncertainty as a function of $\log g$ for giant stars, suggesting that RAVE parallaxes are systematically underestimated for stars with low $\log g$ values in RAVE DR5. In addition, we find the combined uncertainties are overestimated. We suspect that this is due to an overestimate of the TGAS uncertainties by ∼0.2 mas.

In Figure 2 we show the improvement in precision using TGAS parallaxes in the RAVE distance estimates. In the left-hand panel we show the improvement in distance accuracy, divided into that for dwarfs and giants. The median fractional distance uncertainty improves by 200% for dwarfs and 61 % for giants (corresponding to 107% as the median improvement for all stars). For giants (which tend to be more distant in these magnitude-limited samples), the improvement in parallax uncertainty over TGAS alone is 55%.

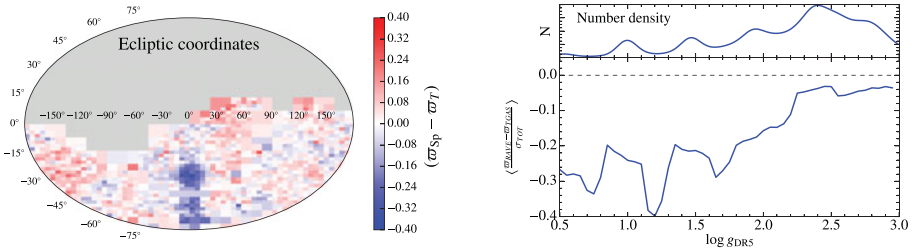

Figure 1. Two plots illustrating problems with TGAS parallaxes (left) and RAVE parallax estimates (right). The left hand plot shows the median difference between the two parallax estimates, binned by position on the sky. The right hand plot shows the median difference between the two estimates divided by the combined uncertainty, as a function of RAVE $\log g$ for giants. The upper panel shows the number density in $\log g$, for reference.

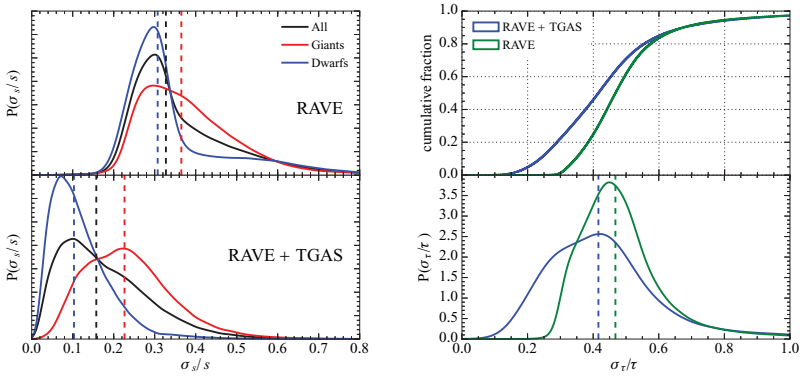

Figure 2. Plots illustrating the improvement in distance uncertainties (left) and age uncertainties (right) when TGAS parallaxes are used. The distance uncertainties are divided in to those for dwarfs ($\log g \geqslant 3.5$) and giants ($\log g < 3.5$). Vertical dashed lines indicate median values.

The right-hand panel of Figure 2 shows the improvement in age uncertainty when using TGAS parallaxes as input. Previously almost no stars had age uncertainties smaller than 30%, but with TGAS around 25% (mostly near the main sequence turn-off) do.

Publication of results.

Full results will be published in McMillan *et al.* (2017, submitted), and released publicly.

Acknowledgement

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