COMPARISON OF THE PLANETARY SYSTEMS FOUND BY DIFFERENT TRANSIT SURVEYS

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Abstract. Over 1200 transiting planets are now known, the majority identified using data from the Kepler space telescope. One of the most interesting subsets of these planets are the hot Jupiters, defined as those with mass $M_b > 0.3 M_{\text{Jup}}$ and orbital period $P_{\text{orb}} < 10 \text{ d}$. These have been identified by a number of transit surveys operating from both above and below Earth’s atmosphere. I present a study of the observable and physical properties of these objects, triggered by curiosity. I include a comparison between WASP and HAT, the two most successful ground-based surveys. Whilst the samples of planets and host stars found by these two surveys are very similar, there is a striking difference of 3σ between the $[\text{Fe} / \text{H}]$ values. This suggests a systematic error of $\sim 0.12 \text{ dex}$ in the metallicity scale of solar-like stars.

Methods. All data used in this work were taken from the July 2015 version of the TEPCat catalogue (Southworth 2011; http://www.astro.keele.ac.uk/jkt/tepcat/). The large number of multi-planet systems identified from Kepler data (Rowe et al. 2014) were not included due to the limited information available for individual planets. The WASP planets include those from the WASP-North (La Palma) and WASP-South (South Africa) installations. I also combined the HATSouth and HATNet planets into a single sample.

Fig. 1. This plot compares the $V$-band apparent magnitude of the transit host stars identified by the four largest transit surveys. The space-based surveys are sensitive to planets around fainter stars. It is noticeable that WASP is more successful than Kepler for magnitudes $V < 12$: the better photometric precision achieved by the satellite is outweighed by the larger number of stars studied by the ground-based survey.

Fig. 2. This plot shows the transit depth of the planets found by the four largest surveys. Kepler is capable of finding the large population of planets with shallow transits, but the ground-based surveys perform better for the rarer systems with deeper transits due to the large stellar sample. Inclusion of all Kepler multi-planet systems in this plot would accentuate the huge number of planets with shallow transits.

Fig. 3 and Fig. 4. The orbital distribution of planets found by different surveys, shown on logarithmic and linear plots. The long and almost continuous observations by Kepler for over 4 years makes its sensitivity to long-period planets unparalleled. The ground-based surveys are better than Kepler at finding planets with periods below 4 days, as these are intrinsically rare but easier to detect.

Fig. 5. Plot of the sky positions of the transiting planetary systems. The discoveries from different surveys are colour-coded (see base of the plot), and the symbol size increases for brighter $V$-band magnitudes. The galactic plane is indicated by a grey dotted line and the celestial equator by a grey solid line.

Fig. 6 and Fig. 7. Comparison between the host stars of planets discovered by the WASP and HAT consortia. The stellar masses and radii are very similar — a two-sided Kolmogorov-Smirnov test ($2\text{KS}$) gives probabilities above 90% that they are drawn from the same distribution — but their atmospheric parameters are not. Whilst the $T_{\text{eff}}$s have a $2\text{KS}$ probability of 15%, that for $[\text{Fe} / \text{H}]$ shows a strong discrepancy at 0.012%. The cumulative distributions require a shift of 0.12 dex to bring the two into good agreement. The discrepancy is beyond the 3σ level, and suggests that systematic errors exist in the $[\text{Fe} / \text{H}]$ scale for solar-like stars.

Fig. 8 and Fig. 9. The planet masses and radii show a similar distribution in the WASP and HAT samples, both with a $2\text{KS}$ probability of around 30% of being drawn from the same population. The double peak at low planet masses in the WASP sample is not significant: a modest change in the choice of bin width can smooth it. The WASP and HAT surveys are yielding planets with comparable properties.

References.  
http://www.astro.keele.ac.uk/jkt/tepcat/