Binary stars in Pennsylvania-Toruń Planet Search

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Niedzielski, A.[1], Wolszczan, A.[2], Jaros, R.[1], Deka-Szymankiewicz, B. [1].

[1]Institute of Astronomy, Nicolaus Copernicus University, ul. Gagarina 11, 87-100 Toruń, Poland, e-mail: jaros@doktorant.umk.pl

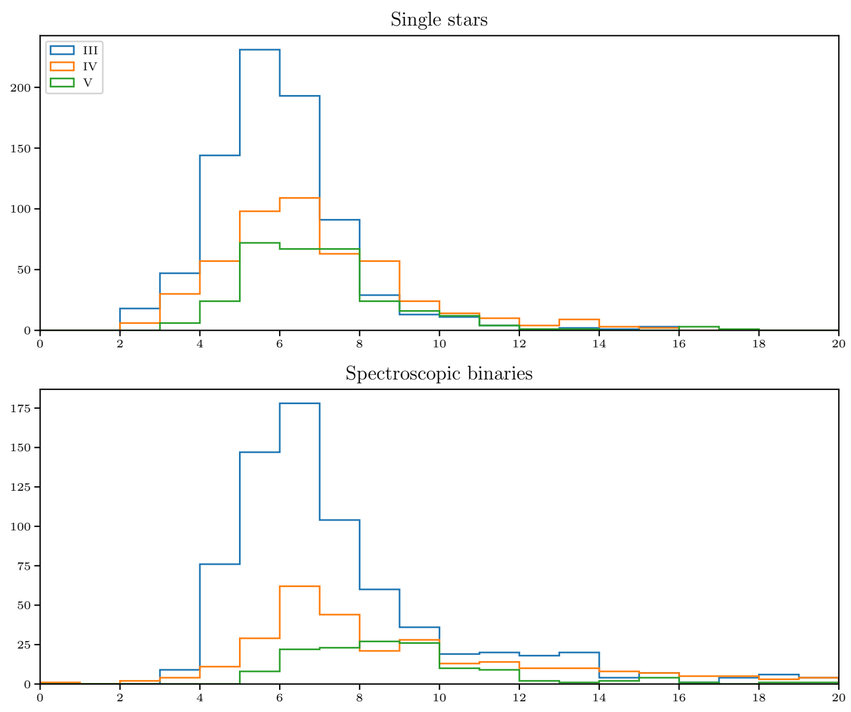
[2] Department of Astronomy and Astrophysics, Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802, USA

Introduction. Pennsylvania-Toruń Planet Search.

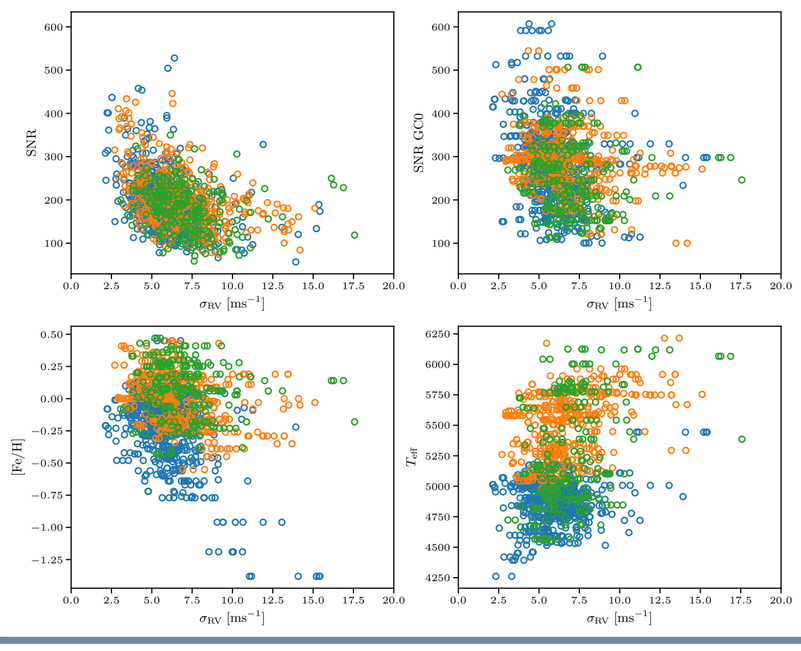
The Pennsylvania-Toruń Planet Search (PTPS) is one of the most extensive RV searches for exoplanets around evolved stars. The project was designed to use the Hobby-Eberly Telescope (HET; Tull 1998) and its High-Resolution Spectrograph (HRS; Ramsey et al. 1998). It has surveyed a sample of stars distributed across the northern sky, with the typical, apparent V magnitudes between 7.5 and 10.5 mag, and the B–V colour indices between 0.6 and 1.3. On the Hertzsprung-Russell diagram, these stars occupy an area delimited by the MS, the instability strip, and the coronal dividing line (Linsky Haisch 1979). In total, the program sample of 885 stars contains 515 giants, 238 subgiants, and 132 dwarfs (Deka-Szymankiewicz et al. 2018). A detailed description of this sample, including their atmosphericand integrated parameters (masses, luminosities, and radii), is presented in a series of papers: Zieliński et al. (2012); Adamów et al. (2014); Niedzielski et al. (2016a); Adamczyk et al. (2016); Deka-Szymankiewicz et al. (2018). The first detection of a gas giant orbiting a red giant star by the PTPS project was reported by Niedzielski et al. (2007). The project is continued within the TAPAS (Tracking Advanced Planetary Systems) project with Harps-N (Niedzielski et al. 2015), and 30 exoplanets were detected so far.

Preliminary results

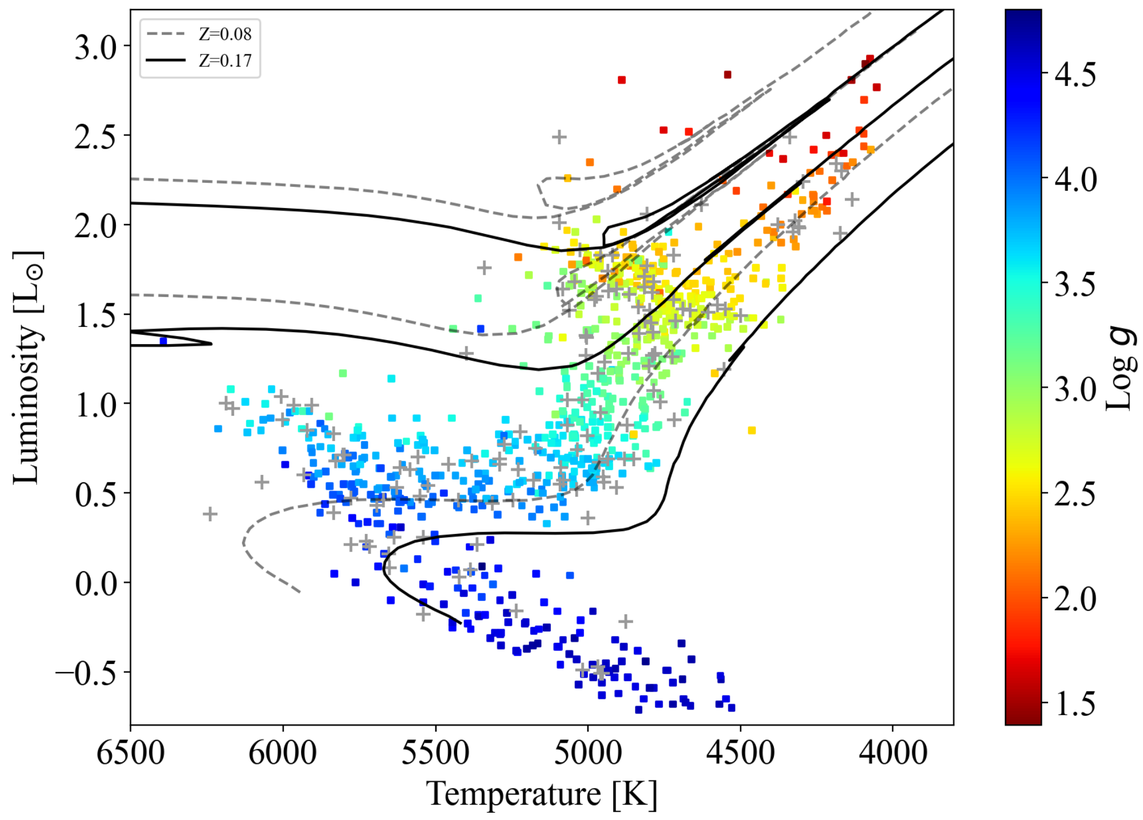
The distributions of HET/HRS radial velocity (RV) uncertainties for single stars and spectroscopic binaries are presented in figure below.



Generally our RV precision for single stars is well below 10 m s^{-1} (97% of giants, 91% of subgiants and 92% of dwarfs). For a substantial fraction of stars it stays below 5 m s^{-1} (28% of giants, 19% of subgiants and 11% of dwarfs). **In figure below we present a relation of the uncertainty in RV (single stars) with the signal-to-noise ratio in the actual spectrum and in template used.** An increase of RV precision with the signal-to-noise ratio in both spectra is clear. In the lower panel we show relations between RV uncertainty and stellar metallicity and effective temperature. A relation between stellar metallicity and RV precision is present in the data. Also a relation between RV precision and stellar effective temperature is clear. We found no other statistically significant relations between stellar parameters and RV precision in our data.



Binary and multiple stars in PTPS



This research project is based on existing, unpublished high precision (typical error of 6-9 m s^{-1}) radial velocity (RV) measurements collected between 2004 and 2014 with the Hobby-Eberly Telescope (HET, Ramsey et al. (1998)) and its High-Resolution Spectrograph (HRS, Tull (1998)). From the initial sample of about 1000 stars monitored within the Pennsylvania-Toruń Planet Search (PTPS, Niedzielski, Wolszczan (2008a)) for 885 detailed spectroscopic analysis was successfully completed (Zieliński et al. 2012; Deka- Szymankiewicz et al. 2018) and resulted in final sample definition.

After acquiring multiple epochs of RV, 517 of these stars were found to be unsuitable for further observations aiming at planetary-mass companions detection. 369 objects were found to present RV variations up to 50 m s^{-1} and, given the expected RV precision of the project at the level of 10 m s^{-1}, were rejected as potentially single stars. Another 121 stars were found to be RV variables at a level above 2000 m s^{-1} and were rejected as potentially stellar binaries. **The complete PTPS sample, with the binary stars indicated as crosses is presented as HRD in figure above.**

Altogether, several thousands of precise multi-epoch RVs will be used in this study of 517 stars. The sample contains 83 dwarfs, 162 subgiants, and 272 giants from the entire PTPS sample. For all of them a full set of atmospheric and integrated stellar parameters is available. The main goal is to present results for the new spectroscopic binaries identified in the sample. Our coarse analysis of the data shows that our sample contains 51 new SBs with enough data to present orbital solutions, 45 systems with not enough data for orbital solutions, for which only preliminary system parameters can be presented based on HET/HRS data alone, and 17 previously identified SBs for which our data can be used to better constrain their orbital solutions.

First (preliminary) estimates of binary frequency in our sample show that: among dwarfs 11±5% stars are spectroscopic binaries, 59±8% appear to be single and 30±7% stars are potentially hosts of low-mass companions; 18±5% of subgiants are spectroscopic binaries, 55±6% are single stars, and 27 ± 5% are potentially hosts of low-mass companions; 14±3% of giants appear binary, 43±4% are single, and 43±4% represent potential planetary/BD-mass companions and/or active stars.

We note that our estimates of single stars fractions among dwarfs 57±4% and subgiants 53±3% are consistent with results of Raghavan et al. (2010) 54±2%. Also our estimate of spectroscopic binaries fraction among (K) giants 15±2%is in agreement with results of Famaey et al. (2005) 13.7%.

Acknowledgements

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