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Constraining RRc candidates using SDSS colours

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Abstract. The light variations of first-overtone RR Lyrae stars and contact eclipsing binaries can be difficult to distinguish. The Catalina Periodic Variable Star catalog contains several misclassified objects, despite the classification efforts by Drake et al. (2014). They used metallicity and surface gravity derived from spectroscopic data (from the SDSS database) to rule out binaries. Our aim is to further constrain the catalog using SDSS colours to estimate physical parameters for stars that did not have spectroscopic data.

1. Method and data

Briefly, Photo-Met estimates the unknown physical parameters of stars by interpolating the known parameters of other stars that have very similar broadband colours. The method relies on two numerical algorithms:
- efficient k-nearest-neighbour finding in a four-dimensional metric colour-colour space and
- local linear regression.

As with any empirical parameter estimation algorithm, the reliability of the entire process depends much more on the training set than on the actual numerical method. For this study, we used an empirical training set based on SDSS PSF magnitudes of approximately 360 000 stars. The stellar parameters [Fe/H], $T_{\rm eff}$ and $\log g$ are the adopted weighted averages from SSPP (SEGUE Stellar Parameter Pipeline). For further details on the method see Kerekes et al. (2013).

The variable list of the Catalina Sky Survey consists of 5467 stars marked as RRc. The cross-match with the SDSS DR10 Cross-ID tool using an $1\farcs2$ radius search resulted in 2762 stars. For delivering new results we took the stars with photometric measurements only (1732 objects) and applied the Photo-Met method to estimate the surface gravity, the effective temperature and metallicity.

2. Constraining candidates

To distinguish between RRc and contact binary stars we applied two criteria:
- RRc stars are halo giants so they are generally expected to have lower metallicity ([Fe/H] < -1) and surface gravity ($\log g < 3.6$) than disk stars.
- Furthermore according to the work of Drake et al. (2014) the RRc stars are concentrated between $0.24 < P < 0.42$ and $0.45 < M_{\rm test} < 0.55$ on the $M_{\rm test} - P$

plane, where $M_{\rm test}$ statistic values is a measure of the fraction of time that an object spends below the mean magnitude. We find 236 objects satisfied both, but 636 objects satisfied none of the criteria.

3. Conclusion

We could identify several contact binaries that were originally classified as RRc stars in the CSS Periodic Variable Star Catalog. The PHOTO-MET method, however, clearly placed them outside the RRc domain set by Drake et al. (2014). We plotted in Fig. 1 four light curves where the asymmetry of the minima can be clearly seen when folded with twice the assumed variation period. However, despite our success in finding new contaminating binary stars in the sample, the large errors in the $\log g$ and [Fe/H] determination (up to ± 1.0 dex) and the low quality of the light curves of faint stars make this method uncertain, leaving a lot of ambiguous objects in the catalog.

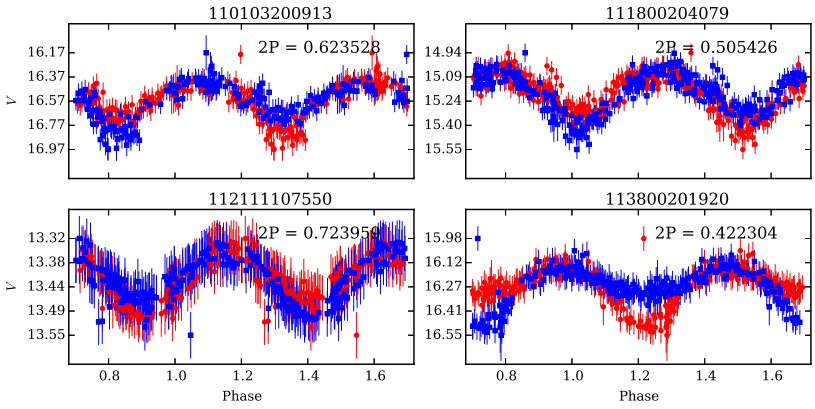

Figure 1. Folded light curves of newly identified eclipsing binaries in the CSS RRc sample. Blue and red points are shifted in phase by 0.5 with respect to each other to highlight the differing minima.

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