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Binary stars in the RAVE survey

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Abstract. We searched the sample of RAVE survey spectra for both types of spectroscopic binary stars in order to estimate their number in the sample and perform a study on newly discovered binaries.

1. INTRODUCTION

Binary stars are often overlooked as an important component of the galactic population. Since their overall fraction in comparison to single stars is high (e.g. [1]), they are inevitably part of any unbiased survey (like RAVE or Gaia, for example). They are often treated as contaminants but binary stars serendipitously harvested in such surveys are interesting objects themselves. The aim of this study of both types of binary stars (SB1 and SB2) in the sample of the RAVE survey is to (*i*) identify binary stars and clean the sample and (*ii*) perform a study on discovered binary stars.

2. RAVE SURVEY

RAVE is an ongoing spectroscopic survey with a goal of measuring radial velocities and atmospheric parameters of up to a million stars using the 6dF multi-object spectrograph on the 1.2m UK Schmidt Telescope of the Australian Astronomical Observatory ([7]). Although the survey is primarily aimed at studying dynamic and structural properties of the Galaxy, the sheer size of the sample of stars (limited only in magnitude, $9 < I < 12$) coupled with a medium resolving power ($R \sim 7500$) enables discoveries of many kinds of peculiar objects, including binary stars. It is possible to detect both kinds of spectroscopic binaries, the single-lined (SB1) as well as the double-lined (SB2) type. The former are discovered by searching for time variations of the objects' radial velocities and the latter can be identified by their signature double-peaked correlation function. The RAVE database consisted of more than 350,000 starts at the time of this study.

3. DOUBLE-LINED BINARIES

The automatic classification of spectra based on the properties of the cross-correlation function (see [3]) yielded 1,122 SB2 candidates that were further examined. Since most of these objects were observed only once it is not possible to infer any orbital parameters, but several atmospheric parameters as well as luminosity ratio can still be calculated. By modeling the binary spectra as a sum of two independent synthetic spectra from the library ([5]) we determined temperatures, surface gravities, Doppler shifts,

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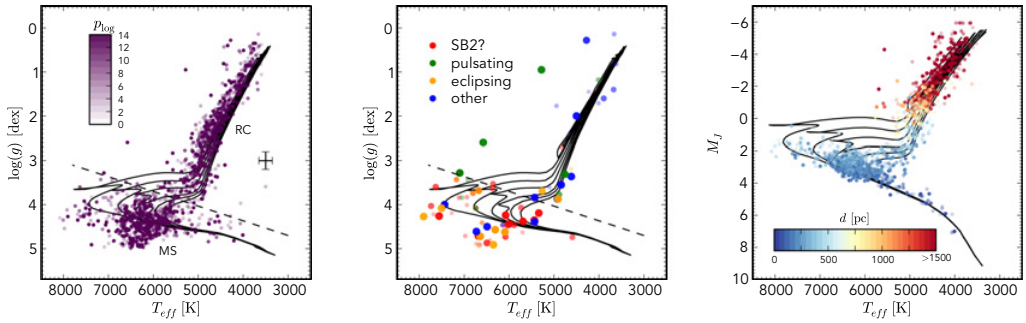

Figure 1. $\{T_{\rm eff}, \log(g)\}$ diagrams of the identified SB1 objects. See text for explanation.

metallicity (presumed to be equal for both components) and luminosity ratio for the whole sample. To better constrain the solutions, surface gravities and luminosity ratio were sourced from the library of stellar models ([2]) by assuming that both components of an SB2 system are main sequence stars (see [3] for further justification). While the number of newly discovered SB2 objects is small compared to the number of stars in the input sample, the contribution to the amount of known close binary systems is still significant.

4. SINGLE-LINED BINARIES

For identification of single-lined binaries repeated observations are necessary. RAVE dedicates $\sim 10\%$ of the observing time for that purpose to evaluate the stability and repeatability of solutions and also to search for binary stars. The sample included 20,027 stars with S/N > 20 for which more than one observation was available. To identify those with variable radial velocities, we defined a variability criterion as a probability that one RV measurement is significantly different from the other given the errors σ (including systematics) of both measurements (see [4]), which can be reduced to $P = \frac{1}{2}\left[1 + \mathrm{erf}\left(\frac{RV_2 - RV_1}{\sqrt{2(\sigma_1^2+\sigma_2^2)}}\right)\right]$. For 1,333 objects the value of $p_{\log} = -\log_{10}(1-P)$ was greater than 3 and those stars are presumed to be SB1 candidates. Fig. 1 shows their positions on the $\{T_{\rm eff}, \log(g)\}$ diagram. It is evident that SB1 objects are present in both the main sequence and the giant population (shown together with distances by [9], on the right diagram). We compared the list of SB1 candidates to the list of known binary stars from the S_{B^9} catalog ([6]). The RVs of all of the matching RAVE stars were consistent with the predicted orbits. The comparison to the VSX catalog of variable stars ([8], middle diagram in Fig. 1) also yielded several hits. Some of the stars with variable radial velocities turned out to be pulsating variables, but the fraction of such stars among SB1 candidates is small. The overall fraction of binaries present in the RAVE sample is estimated at 10–15%, depending on the lower limit of the variability criterion.

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