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Digging out twin-binary star systems from the ASAS catalogue and determining their physical parameters

V. Bakış[1], **O. Sarı**[1], **G. Yücel**[1], **E. Sonbaş**[2] **and H. Bakış**[1]

[1] *Department of Space Sciences and Technologies, Akdeniz University, Dumlupınar Boulevard 07058 Antalya, Turkey, (E-mail: volkanbakis@akdeniz.edu.tr)*

[2] *Department of Physics, University of Adıyaman, 02040, Adıyaman, Turkey*

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Abstract. We have studied the ASAS catalogue in search of detached binary systems with identical components. The selected systems were photometrically and spectroscopically observed for spectral type determination. The light curves available in the ASAS database were analyzed and the light curve parameters once combined with the spectroscopic information yielded the spectral types of the binary stars in our twin candidate list. The spectral type distribution of twin binaries has shown a clear peak at the F-spectral type. Moreover, it is noteworthy that the number of twins with the A-spectral type is comparable to those with the G-spectral type, which is in contrast to previous studies.

Key words: eclipsing binaries: twin binaries, techniques: photometry, techniques: spectroscopy

1. Introduction

Studies on the mass distributions of binary stars (e.g. Lucy, 2006; Simon & Obbie, 2009) show that the ratio of twins with a mass ratio of q (M_2 / M_1) = 0.98-1.00 is around 3 percent and that the F, G and K spectral species are dominant. Simon & Obbie (2009) has 1 O, 1 B, 3 A, 16 F, 11 G and 3 K-type stars in the example list. This statistics led Simon and Obbie (2009) to make a suggestion that small-mass twins are in binary star populations where the accreation process in the star formation is slower. In addition, the presence of twins with the early-spectral type suggests that binary stars with components with masses larger than 1.6 solar masses may have the same formation mechanism as binary stars with smaller mass stars (Zinnecker & Yorke, 2007), but different mechanisms may also be important (Simon & Obbie, 2009). For this reason, it is obvious that the determination of the spectral type distribution among the twin stars will generally contribute to the understanding of star formation, and, in particular, to the understanding of twin binary stars.

Simon & Obbie (2009)'s statistical work has benefited from the SB9 (Pourbaix et al., 2004) catalog, which is the spectral catalog of binary stars and constantly updated on the internet. Therefore, a systematic search of twin binaries by means of photometric and spectroscopic observing techniques is a necessity to do a more reliable statistics on their parameters.

2. Determination of twins

2.1. The database

The observational database to be investigated for twin binary stars must be free of selection effects such as limitation of a particular spectral type stars or orbital period etc. The ASAS catalogue (Pojmanski, 1997) is very suitable for our purpose since it consists of all sky photometric observations of targets down to 14th magnitude and no orbital period or spectral type limitation exist in the catalogue.

2.2. Binary selection

We needed detached binary stars so that they did not make any mass transfer between the components and the components still have the same mass at their birth. Such binary systems have components that have similar temperature and radii, therefore, the primary and secondary minima in the light curves must be identical. Thus, the ASAS catalogue are searched for such light curves for a preliminary selection.

The observability was also considered during the preliminary selection. The systems to be analyzed must also be observable in Turkey. Thus, we have limited our all sky to a declination of > -32 deg. Assumign the twins are evenly distributed in the sky, the selection of the sky region does not make a selection effect. The declination and right ascension distribution of the selected twin candidates are shown in Fig.1.

2.3. Light curve analysis

The light curves of the selected systems are analyzed with the Wilson-Devinney method (Wilson & Devinney, 2003). The number of analyzed systems is 240. The analysis yielded the the ratio of temperature and radii of the components. The systems with the ratio of temperature and radii in between 0.95-1.00 are selected for observation for a more reliable spectral type determination. Among the analyzed twin candidates, 71 systems are found to be twins. A sample light curve model fitted to a twin candidate is shown in Fig.2.

2.4. Observations of candidate twins

Observations of the selected twin binary candidates are done in two observing sites, TUBITAK National Observatory (TUG) in Antalya and Adıyaman University Observatory in Adıyaman. In TUG, three telescopes are used, a 1.5-m

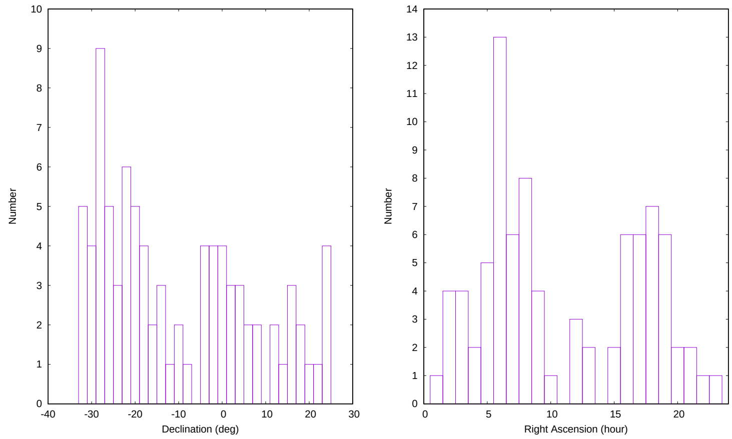

Figure 1. Sky distribution of the targets observed in this study. The left panel is for declination and the right panel is for right ascension. In the panels, the binning of the data was chosen to be 2 deg for declination (*left*) and 1 hr for right ascension (*right*).

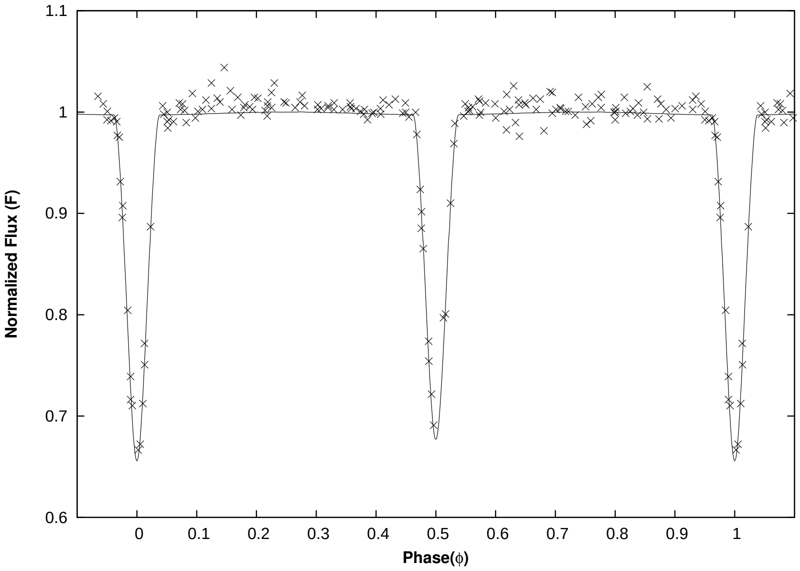

Figure 2. A sample of light curve model of a twin candidate from the ASAS catalogue.

RTT150 telescope and a 0.6-m UBT60 telescope for medium resolution spectroscopy, and a 1-m (T100) telescope for multi-band imaging. In Adıyaman, the 0.6-m telescope is used for only multi-band imaging. A sample spectrum of a 8.46 mag ASAS star is shown in Fig.3.

In photometric observations, $UBVRI$ Johnson filters were used with both telescopes and the telescope standart coefficients are calculated precisely for a reliable absolute photometry. Once the colors (U–B, B–V, V-R and V-I) are obtained, stars without spectroscopic observations are plotted in the color-color diagrams and spectral types together with interstellar extinction were estimated by moving the stars in the opposite direction of interstellar extinction. The interstellar extinction was used to obtain reddening-free colors, which are used to estimate temperatures of the twins.

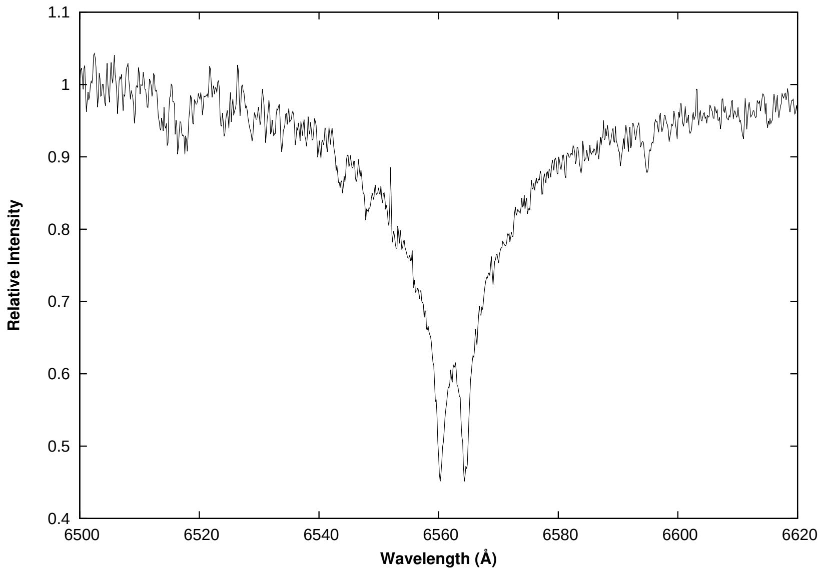

Figure 3. A sample spectrum around the H_α region of an 8.46 mag twin candidate from the ASAS catalogue.

3. Preliminary results

In this project, a total of 71 twin canditates from the ASAS catalogue are determined and observed. Their spectral types are determined either by photometric or spectroscopic data. If a spectral data exists for a system, the spectral type is determined directly from the spectral data otherwise from the colors obtained by absolute photometry. The spectral type distribution of the twins is shown in Fig. 4. In Fig. 4, a peak at the F-spectral type is clear, which is in agreement with the recent study by Simon & Obbie (2009). However, it is new that the number of twins with the A-spectral type is more than those with the G-spectral type.

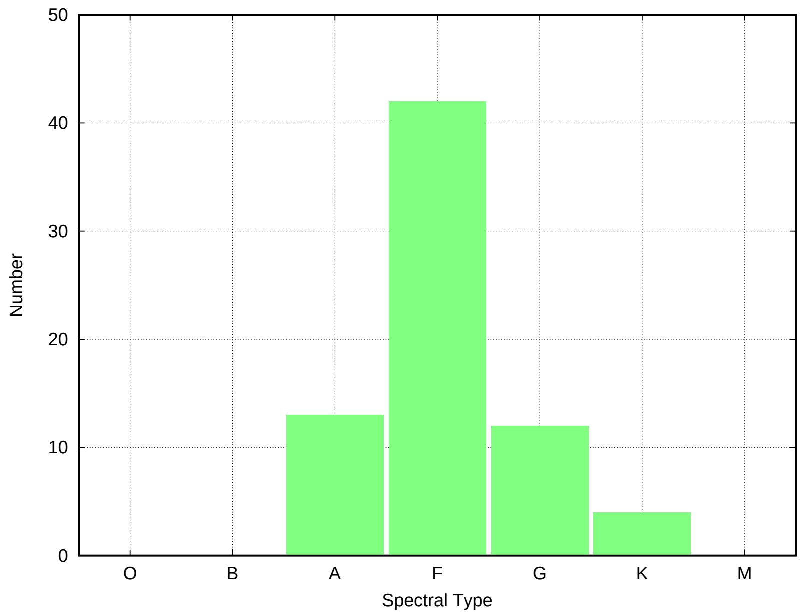

Figure 4. Spectral type distribution of twin binaries in the ASAS catalogue.

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