Abstract. We present photometric results obtained by our group as part of a photometric follow-up of transiting exoplanets carried out with the INTA-CAB 50 cm robotic telescope at Calar Alto Observatory (Almería, Spain). We compare light curves of different exoplanets taken with this telescope under different observing conditions and show that we are improving our previous results after the renewal of part of the equipment.

Keywords: astrobiology – methods: observational – techniques: photometric – planetary systems

1. Introduction

Extrasolar planets (or exoplanets) have been extensively searched during the last two decades. As a result of this effort, since 1995 - when the first exoplanet was discovered by Mayor & Queloz (1995) - there are now more than 700 confirmed exoplanets (to date, over 800 exoplanets are listed in the Extrasolar Planets Encyclopaedia (http://exoplanet.eu)). Most of the planets have been detected with the radial velocity method (using high resolution spectrographs), but other techniques are also good to detect extrasolar planets. The second most productive indirect technique of detection is the transit method. When a planet crosses (or transits) in front of its parent star, the observed brightness of the star drops by a small amount. The amount by which the star dims depends on its size and on the size of the planet, among other factors.

WASP-1b is the name of the exoplanet orbiting the parent star WASP-1. It was discovered in 2006 and is supposed to be a hot Jupiter with metal-rich atmosphere, little or no core, and its age is less than 1.5 Gyr (Stempels et al. 2007). Charbonneau

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et al. (2007) obtained a period of 2.51997 days. The star WASP-1 has an apparent magnitude in the V band of 11.79 mag and its spectral type is F7V.

WASP-3b is a transiting exoplanet discovered by Pollacco et al. (2008) and confirmed by Gibson et al. (2008). It transits its host star WASP-3 every 1.84683 days. The proximity and relative temperature of the host star ($T_{\text{eff}} = 6400$ K and spectral type F7-8V) suggests that WASP-3b is one of the hottest exoplanets known. WASP-3 has an apparent magnitude in the V filter of 10.64. Here we show photometric results of these two transiting exoplanets.

2. Observations

We present some light curves obtained by the Robotic Telescopes Group of Centro de Astrobiología (placed in the campus of INTA in Torrejón de Ardoz, Madrid, Spain). These results are part of a photometric follow-up of known transiting exoplanets carried out with the 50 cm robotic telescope at Calar Alto Observatory (Almería, Spain). The 50 cm robotic telescope is remotely operated from Madrid and, in summer of 2010, part of the equipment was renewed. Thus, in order to compare the photometric precision obtained before and after these changes, we show data taken on 2010 April 29 and 2010 October 20.

In Table 1 we present the characteristics of the CCD cameras that we used before and after 2010 September 3, when renewal of part of the equipment was made (CCD camera and new filters).

During the night of 2010 April 29, the telescope was equipped with a 4008 $\times$ 2672 Finger Lakes Instrumentation (FLI) ProLine PL11002M Interline CCD camera. The pixel scale was 0.37 arcsec/pixel and the total field of view 24 $\times$ 16 arcmin². We only observed WASP-3 with the R filter on that night. The exposure time was 50 seconds for all the images, and the FWHM of the seeing disc had values of around 2.5 arcsec. We used a binning of 2 $\times$ 2, involving a pixel scale of 0.74 arcsec/pixel. The exposures were taken with the telescope focused.

During the night of 2010 October 20, the detector was a 3056 $\times$ 3056 FLI ProLine...
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Figure 1. Transit light curve of WASP-3 observed with the INTA-CAB 50 cm robotic telescope in the R band (2010 April 29). Differential magnitude is plotted versus time (Julian Day).

PL09000 CCD camera. The pixel scale was 0.5 arcsec/pixel and the total field of view was 25 x 25 arcmin². We observed WASP-1 and WASP-3 on that night. In the case of WASP-1, the exposure time was 55 secs for the R band and 65 secs for the V filter. For WASP-3, exposure times were 32 secs in the R filter and 42 secs in the V band. In order to test the characteristics of the new CCD camera (pixel scale and readout time), a binning of 1 x 1 was used for all the series in that night.

3. Photometry

We used a pipeline for the automatic reduction of data consisting of two independent parts. The first one makes standard CCD corrections as well as the search of the exact solution for the WCS (done by calling Astrometry software online (http://www.astrometry.net/use.html)). The second part must be done separately when using images of different objects and/or filters. This way, for each data set, the system performs the differential photometry of the target with respect to a collection of suitable comparison stars found in that set. We consider that a star is a good candidate to be a reference one (comparison star), if it is close in magnitude to the target and it is constant enough over the whole series. More details about this can be found in Eibe et al. (2011).

In Fig.1 we display the transit light curve of WASP-3 observed in April 2010 with the R filter, whereas in Fig. 2 we show the photometric results (out-of-transit data) obtained for WASP-1 using the R filter and in Fig. 3 we present the light curve...
Photometry of WASP-1 (20/10/10, R filter)

Figure 2. Photometric results (out-of-transit) of WASP-1 observed with the INTA-CAB 50 cm robotic telescope in the R band (2010 October 20). Differential magnitude is plotted versus time (Julian Day).

Photometry of WASP-3 (20/10/10, V filter)

Figure 3. Photometric results of WASP-3 observed with the INTA-CAB 50 cm robotic telescope in the V band (2010 October 20). Differential magnitude is plotted versus time (Julian Day).

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(2011), for further details). The errors obtained were 4 mmag for the transit of WASP-3 (R band), 4 mmag for the photometric results of WASP-1 (in R and V filters, V not shown here) and 3 mmag for WASP-3 (out-of-transit) in the V band. In order to obtain robust photometric results, it is important to notice the necessity of a relatively large set of suitable comparison stars in the same field as the target when doing differential photometry. In Fig. 1 we used six neighboring reference stars, whereas eight stars were used for obtaining the photometry of WASP-1 (Fig. 2) and nine comparison stars in the case of WASP-3 (results of Fig. 3).

In Fig. 1, WASP-3 shows signs of short-time variability during the transit, with fluctuations that are above the photometric precision of the data (see Eibe et al. (2011) for further information). Figs 2 and 3 show the photometric behavior of the host stars WASP-1 and WASP-3, respectively, when there is no transit of their exoplanets. There are 126 points in Fig. 2, whereas only 48 measurements are plotted in Fig. 3. In the first case, a clearly constant behavior of WASP-1 can be seen. For the case of WASP-3, that behavior is not so evident because we had just a few measurements that night but, in any case, the slight variability is below the photometric error of the data. Previous works show no evidence of a high level of activity of this star (Gibson et al. 2008; Pollacco et al. 2008). Despite that, Tripathi et al. (2010) and Christiansen et al. (2011) found signs of variability of this star.

These light curves should be considered preliminary results, since further analysis must be done. The main goal of this work was to compare the photometric results of the INTA-CAB 50 cm robotic telescope under different observing conditions. In this case, we can conclude that a robotic telescope of this size is very appropriate when doing ground-based photometric follow-up of transiting exoplanets, and regular maintenance of the equipment is needed for that purpose. Thus, in April 2010 we needed exposure times of 50 seconds for observing WASP-3 in the R band, while in October 2010 (after the maintenance work) we only needed 32 seconds for obtaining similar SNR when observing the same target with the same filter. Furthermore, in the first case we used a binning of $2 \times 2$, what usually requires considerable shorter exposure times than when using a binning of $1 \times 1$ (case of October 2010 observations). In this sense, we note the improvement obtained when using the new CCD camera, as well as new filters. At this moment, we are testing new configurations in order to optimize the response of the detector. In the near future, we will show even better photometric results.

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References