RevMexAA (Serie de Conferencias), **40**, 291–292 (2011)

HIGH CADENCE NIR OBSERVATIONS OF EXTRASOLAR PLANETS

C. Caceres,[1] V. D. Ivanov,[2] D. Minniti,[1] D. Naef,[3] C. Melo,[2] F. Selman,[2] E. Mason,[4] and G. Pietrzynski[5]

RESUMEN

Un segundo paso en la caracterización de planetas extrasolares ha sido alcanzado con la detección de la emisión térmica, por medio de observaciones de las curvas de luz de estos objetos, en su fase de eclipse secundario. Utilizamos observaciones de alta resolución temporal en el infrarrojo cercano para detectar los eclipses secundarios y los tránsitos primarios de algunos planetas extrasolares observables desde el sur, las que producen una caracterización de alta precisión de estos sistemas.

ABSTRACT

A second step in the characterization of extrasolar planets has been achieved with the detection of the planetary thermal emission by observing the occultation-phase light curves of these objects. We use near-infrared high-cadence observations to detect the occultation and the primary transits of some southern extrasolar planets which produce a highly accurate characterization of these systems.

Key Words: planetary system — techniques: photometric

1. INTRODUCTION

Around 520 extrasolar planets are known to date[6], mostly discovered with the radial velocity searches, and roughly 20% of the total number of known planets transit their host stars. They are the only ones with a complete description of their physical and stellar parameters.

Here we use IR detectors to get high time resolution light curves of primary transit and secondary eclipses of some southern extrasolar planets. The IR detectors allow us to obtain imaging with minimum "dead" time for readout. By design the IR detectors read out faster than the CCDs because the high background forces the usage of short exposures, and the IR array technology has evolved to achieve reset/readout times of order of microseconds. This gives us the following advantages: (i) we observed with unprecedented time resolution of around 0.1–0.6 sec; the host stars on individual images have S/N 50–100, depending on the band and the target brightness; (ii) we observed bright planet hosting stars without defocusing, as it is often the case with the previous studies that attempted to use larger telescopes, reducing the contamination from nearby sources; (iii) we relied on the ESO timing system that provided us with uniform time accurate to better than 0.1 s, minimizing any systematic effects – a crucial advantage over other studies that rely on collecting data from various telescopes.

2. OBSERVATIONS AND DATA REDUCTION

For obtaining these high cadence light curves we use the following IR instruments located in Chile: SofI (Moorwood et al. 1998a) mounted at the 3.6 m NTT in La Silla, and ISAAC (Moorwood et al. 1998b) mounted in the 8 m UT3 telescope (Melipal) at the VLT. The observations makes use of a windowed detector, that allow us to access short exposure times. The selected window has to include the target star plus at least one reference star of similar brightness to apply differential photometry. The FastPhot mode of ISAAC and SofI stores each image in one data cube of length NDIT frames, and the time between two frames is negligible. This operation minimizes the dead time between exposures, ensuring a maximum coverage of the physical phenomena to observe. The typical lost time for reading/transferring the information is of the order of ∼5–6 seconds, after each cube is completed. More details can be found in Caceres et al. (2009).

Our experience with this kind of observations shows us that aperture photometry is enough for our purposes, as the usual low number of bright stars in

[1]Departamento de Astronomía y Astrofísica, P. Universidad Católica de Chile, Av. Vicuña Mackenna 4860, 7820436 Macul, Santiago, Chile (cccacere@astro.puc.cl).

[2]European Southern Observatory. Av. Alonso de Cordova 3107, Casilla 19, Santiago 19001, Chile.

[3]Observatoire de Geneve, Universite de Geneve, 51 Ch. des Maillettes, 1290 Sauverny, Switzerland.

[4]ESA-STScI, 3700 San Martin Drive, Batlimore, MD 21218, USA.

[5]Department of Astronomy, Universidad de Concepción, Casilla 160-C, Concepción, Chile.

[6]An updated list of the current extrasolar planets could be found in `http://exoplanet.eu`.

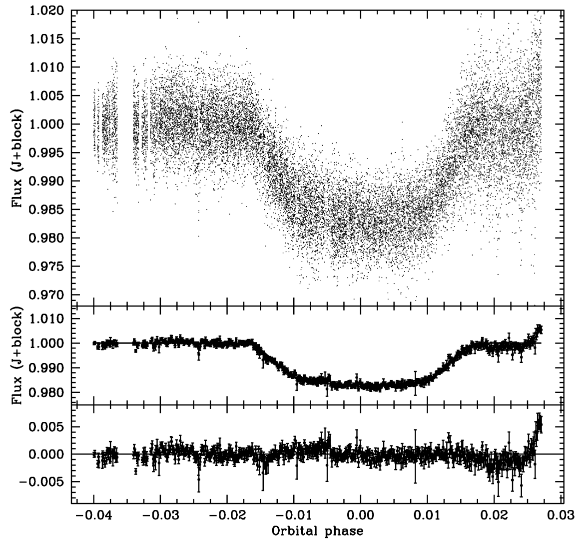

Fig. 1. A high time resolution light curve of the primary transit of the hot extrasolar planet WASP-2b. The upper panel shows the complete light curve, with its approximately 18,000 points. The mid-panel shows the light curve where each point represents a 20 seconds bin, with a final r.m.s. of around 1 mmag. The bottom panel shows the residuals after removing the best fitting model of a transit.

the detector field of view limits the application of, for instance, PSF or deconvolution photometry.

3. RESULTS AND DISCUSSION

We applied this high cadence method to analyze the transits of the extrasolar planet WASP-2b. This planet was discovered by Collier-Cameron et al. (2007). It is a $0.88 \pm 0.11\ M_J$ planet with radius of $0.95 \pm 0.3\ R_J$, around the star WASP-2 in a 2.15226 day period orbit. The obtained light curve, in the J filter, is shown in Figure 1. The best fitting model in this case includes a quadratic limb-darkening law, with parameters obtained from Claret (2000), and the shape of the model follows the prescriptions of Mandel & Agol (2005). The fitting procedure includes as free parameters the central time of the transit T_C, the planet-to-star area ratio p, and the inclination angle i. The determination of the errors in the parameters was carried out with a bootstrapping simulation, similar to the procedure described in Caceres et al. (2009). This procedure takes into account the effects of the correlated noise (e.g. Pont et al. 2006) in the obtained light curve.

We also applied this technique to the secondary eclipse of the planet WASP-4b (Wilson et al. 2008), in the K_S filter. The obtained light curve is shown in Figure 2. The fitting procedure is similar to the one

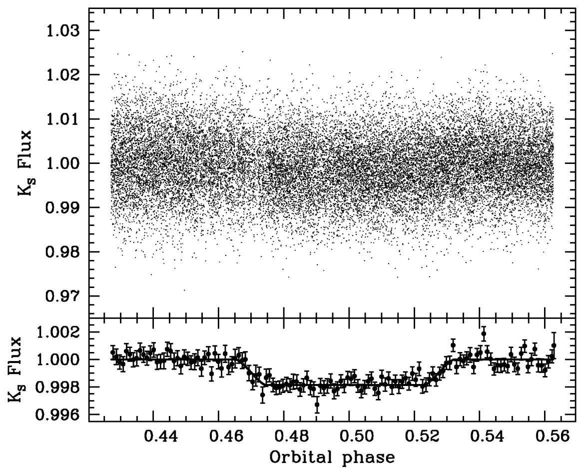

Fig. 2. A high time resolution light curve of the secondary eclipse of the highly irradiated extrasolar planet WASP-4b. The total number of points in the complete light curve is approximately 25,000, and the r.m.s. achieved in the binned figure is around 0.5 mmag. The best fitting model is shown in the second panel, and it considers a zero limb darkening.

of WASP-2b, but in this case the secondary eclipse model corresponds to a transit model without limb-darkening, and with a depth scaled to the desired depth. The free parameters in this case are the central eclipse time T_C, the depth d, and the eclipse length τ_e.

The high-cadence method described here is an excellent tool for obtaining accurate light curves of transits of extrasolar planets, that allow a good characterization of its physical parameters. The challenging detection of the thermal emission in the NIR is also within the capability of this method, and it is a good complement to space based observations.

This work is supported by ESO, by BASAL Center for Astrophysics and Associated Technologies PFB-06, by FONDAP Center for Astrophysics 15010003, and by MIDEPLAN Milky Way Millennium Nucleus P07-021-F.

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