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Photometric follow-up of transiting extrasolar planets and the HATSouth survey

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Abstract

We present the most recent results of our project aimed to obtain accurate properties of known extrasolar transiting planets (TEPs) via photometric follow-up. We also describe the status of the HATSouth project, whose primary purpose is to detect and characterize a large number of TEPs.

1. Introduction

The main purpose of our project is to obtain simultaneous high-precision differential photometry of complete planetary transit events, which are analysed to measure the physical properties of the corresponding planetary systems. At present many of the 298 known TEPs do not have high-quality follow-up light curves, and so their properties are relatively uncertain. We are therefore conducting a long-term project to observe these objects from both the hemispheres with medium-class telescopes. The observations are performed using the defocussing technique, which allows a good control of systematic effects and therefore a much better photometric precision [8].

2. Simultaneous follow-up of TEPs

Anomalies in transit light curves can arise from several phenomena affecting the parent stars, such as gravity darkening, stellar pulsation, starspots and even the presence of exomoons. High-quality photometric observations are therefore not only important to accurately determine the physical parameters of TEP systems, but can disclose further astrophysical information. However, even if we use the telescope-defocussing method, it is generally a hard task to recognise transit anomalies due to astrophysical effects from those caused by random or systematic noise attributable to instrumental or atmospheric effects. One solution is to monitor the same transit event simultaneously from two telescopes located at different sites. If both the telescopes notice the same anomaly, we can discard the possibility that it is caused by instrumental or Earth-atmosphere effects. We successfully implemented this observational strategy to follow up several planetary transits by using the Cassini 1.5m telescope at the INAF/Astronomical Observatory of Bologna in Loiano, and the CA 1.23m telescope at the German-Spanish Astronomical Centre at Calar Alto. These two telescopes are sufficiently distant from each other that their observations are completely independent in terms of instrumental effects and atmospheric conditions, but close enough that they can contemporaneously observe the same transit event [3, 2]. An example of this observational strategy is reported in Fig. 1, which show a clear anomaly detected by the two telescopes during a planetary-transit event of HAT-P-8b.

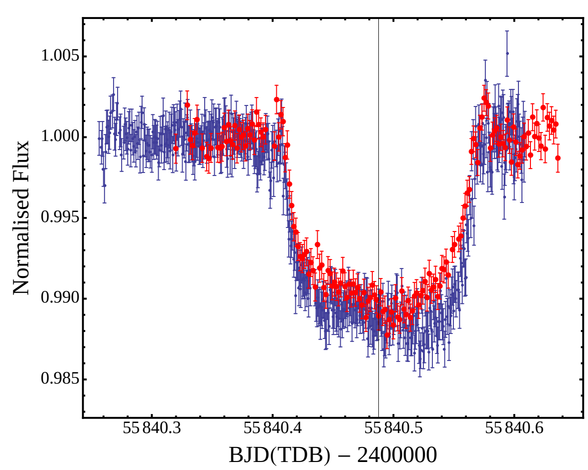

Figure 1: An example of the consistency of follow-up observations of HAT-P-8 made on the same date from two different observatories. Blue dots are for the data taken at the Cassini 1.52m telescope, the red ones for those taken at CA 1.23m telescope [3].

3. Multi-colour follow-up of TEPs

An interesting technique, alternative to the transmission spectroscopy and useful to probe the atmosphere of TEPs, is to study their transits with simultaneous photometry at different wavelengths. This observational strategy allows to measure the radius of TEPs in each bandpass filters and to look for possible variations that can be attributable to the absorption of the light from the parent stars at specific wavelengths due to atoms and/or molecules in their atmospheres. We are exploring this science case by using two imaging instruments designed for simultaneous multi-colour photometry, i.e. BUSCA mounted at the CA 2.2m telescope and GROND at the ESO/MPG 2.2m telescope in La Silla [9, 4]. In particular, GROND is able of simultaneous photometric observations in four optical (identical to Sloan g', r', i', z') and three NIR (J, H, K) passbands.

As an example, GROND observations of two planetary transits of HATS-2b are reported in Fig. 2. In both the cases, anomalies were detected and interpreted as the consequence of the planet crossing irregularities on the stellar photosphere, i.e. starspots [6].

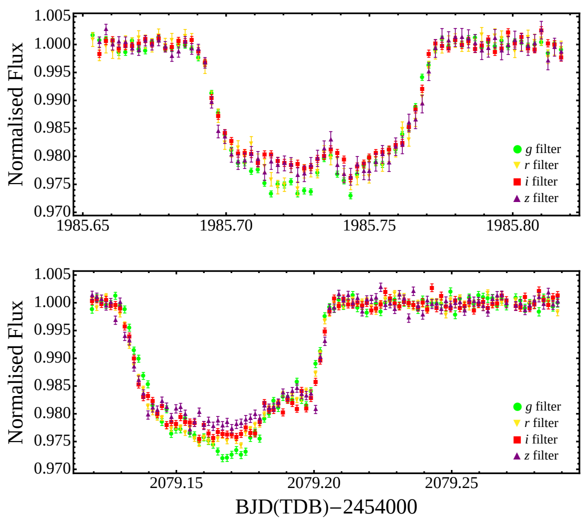

Figure 2: Combined four-colour transit light curves of HATS-2 obtained with GROND. Top panel: the bump observed just after the midtransit is interpreted as the covering of a "cold" starspot by the planet. Lower panel: in addition to the bump occurred near the egress part of the light curve, a "hot" spot manifested in the g' band, just before the starting of the covering of the starspot [6].

As another example, the variation of the radius of WASP-19b, in terms of planet/star radius ratio, with wavelength is shown in Fig. 3, where data from GROND are in black. The vertical bars represent the errors in the measurements and the horizontal bars show the full widths at half maximum transmission of the passbands used. The experimental points are compared with a synthetic spectrum that does not include TiO and VO opacity. The atmosphere of WASP-19b results dominated by absorption by H_2O, Na, and K, and no evidence for a strong optical absorber at low pressure, which agrees well with the fact that WASP-19b's atmosphere lacks a dayside inversion.

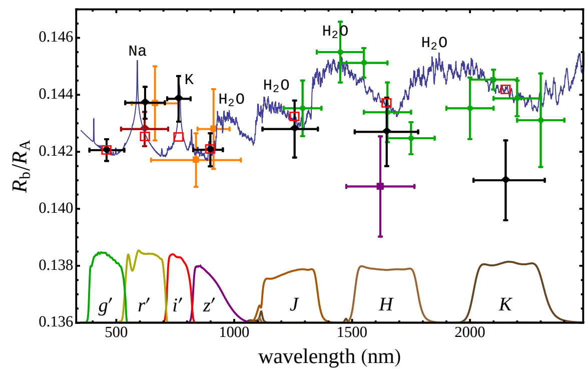

Figure 3: Variation of WASP-19b's planetary radius with wavelength. Black points are from GROND, the other coloured points are from literature. Red open boxes indicate the predicted values for each of the two models integrated over the passbands of the observations. Transmission curves of the GROND filters are shown at the bottom of each panel. Prominent absorption features are labelled [5].

4. The HATSouth survey

HATSouth is a new ground-based survey dedicated to detect new TEPs. It consists in a network of six identical, fully automated wide field telescopes, located at three sites (Chile: Las Campanas, Australia: Siding Springs, and Namibia: HESS site) in the southern hemisphere. The three sites permit near round- the-clock monitoring of selected fields, providing a massive improvement in detection efficiencies for planets at $5 - 10$ day periods [1]. The operation of HATSouth is a collaboration among the MPIA, the Princeton University, the Pontifical Catholic University of Chile, and the Australian National University. HATSouth has currently published two TEPs [6, 7] and confirmed several others over 300 candidates. We illustrate the details of the experiment and show the results achieved so far.

Figure 4: The two HATS stations in Namibia.

References

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