RevMexAA (Serie de Conferencias), **42**, 10–11 (2013)

RESULTS OF THE FIRST EXOPLANET TRANSMISSION SPECTROSCOPY ATTEMPT WITH GTC

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RESUMEN

En junio del 2011 intentamos medir el primer espectro de transmisión de un planeta extrasolar con GTC. Observamos el Júpiter caliente TrES-2b durante dos tránsitos, usando el modo de espectroscopía de larga rendija de OSIRIS. La técnica consiste en hacer espectro-fotometría diferencial situando el objeto y estrella de comparación simultáneamente en la rendija, y observación continua durante la duración completa del evento, para obtener en simultáneo observaciones del tránsito entre ∼5000 y 9000 Å. Aquí presentamos los resultados de nuestro primer intento de uso de esta técnica, que puede mejorar en un factor de 5 a 10 la eficiencia en observaciones de tránsitos primarios y secundarios de exo-planetas con GTC. Presentamos además un resumen de la ciencia hecha hasta ahora con las observaciones del programa ESO/GTC 182.C.2018.

ABSTRACT

In June 2011 we attempted to measure the first atmospheric transmission spectrum of an exoplanet with the GTC. We observed the hot Jupiter TrEs-2b during two transit epochs using the long-slit spectroscopic mode of OSIRIS. The technique consists of doing differential spectrophotometry by placing the planet host and a nearby star on a wide slit during a planetary transit. We then monitor both objects for the duration of the event to obtain simultaneous transit coverage at wavelengths between ∼5000 and 9000 Å. We present here the results of our first attempt with this new technique, which holds the potential of providing a 5–10 fold improvement on the efficiency of exoplanet primary and secondary eclipse observations with the GTC. Finally, we also present a summary of the science done so far with observations from the ESO/GTC program 182.C.2018.

Key Words: planets and satellites: atmospheres — techniques: spectroscopic

1. INTRODUCTION

The discovery of the first exoplanets now dates back almost 20 years. As result, more than 700 planets have now been discovered, covering a wide range of parameters (see `http://exoplanet.eu`). With such large number of discovered planets, it is now possible to go one step further and start learning about the physical properties of their atmospheres. There are currently two ways to study the atmosphere of exoplanets: via direct imaging or via transits. Via transits one can study the atmosphere of a planet by (1) observing the drop in light when the planet passes behind the star (secondary transit). That gives a measurement of the emission of the planet, or (2) observing the extra absorption of stellar light as a function of wavelength, which is called the *transmission spectrum*, when the planet passes in front of the star (primary transit), which gives information about chemicals present in the atmosphere of the exoplanet. In this work we describe our attempt to detect the transmission spectrum of TrES-2b using long-slit spectroscopy and the results of tunable filter observations of XO-2b and HAT-P-1b.

2. OUR OBSERVATIONS

The observations were done using the long-slit spectroscopy and the tunable filter modes of OSIRIS.

2.1. *Long-Slit Spectroscopy*

We observed two transits of the hot Jupiter TrES-2b on June 13/14 and June 18/19 2011 UT with the OSIRIS R500R grism and a custom-designed $8.6' \times 5''$ slit. The slit was rotated 296 deg to include the target and a nearby comparison star on the slit. We also defocused to the equivalent of $2''$ seeing to minimize the effect of resolution variations in the spectra. Each transit was monitored for four hours, with

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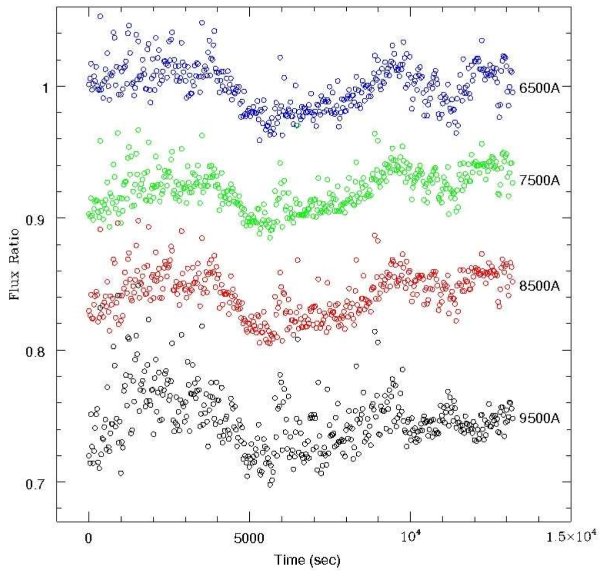

Fig. 1. Long-slit transit observation of TrES-2b.

a duty cycle of 42 sec per image (35 sec exposure + 7 sec readout). The observations were done using 2×2 binning and a readout speed of 500 kHz. We obtain in this way simultaneous spectra of the planet between ∼5000 and 9000 Å.

2.2. *Tunable Filters*

The tunable filters (TF) observations are part of an ESO/GTC program led by D. Sing. The program was granted 180 hours to observe 11 hot Jupiters and one super-Earth between 2009 and 2012, with 38% of the observations completed to date. For the planets presented in this work, XO-2b and HAT-P-1b, we observed three separate transits centered at 6792.0 Å, 7582.0 and 7664.89 Å (these two wavelengths covered during a single transit switching successive images between the two), and 8839.0 Å. The 7664.89 Å observation is centered on a K I line core. We used the narrowest TF width available (12 Å), 1×1 binning, and a readout speed of 500 kHz. The target and comparison star were placed on the image such that they were at the same radial distance from the center, so the TF is centered at the same wavelength for both objects. For XO-2b we monitored each event over full transits. For HAT-P-1b, two of the transits were monitored in full and two (the simultaneous transits at 7582.0 and 7664.89 Å), started at the end of ingress. The duty cycle of the observations varied between ∼20 and 113 sec per image.

3. RESULTS

The result of the long-slit observations are shown in Figure 1. Each curve corresponds to the transit

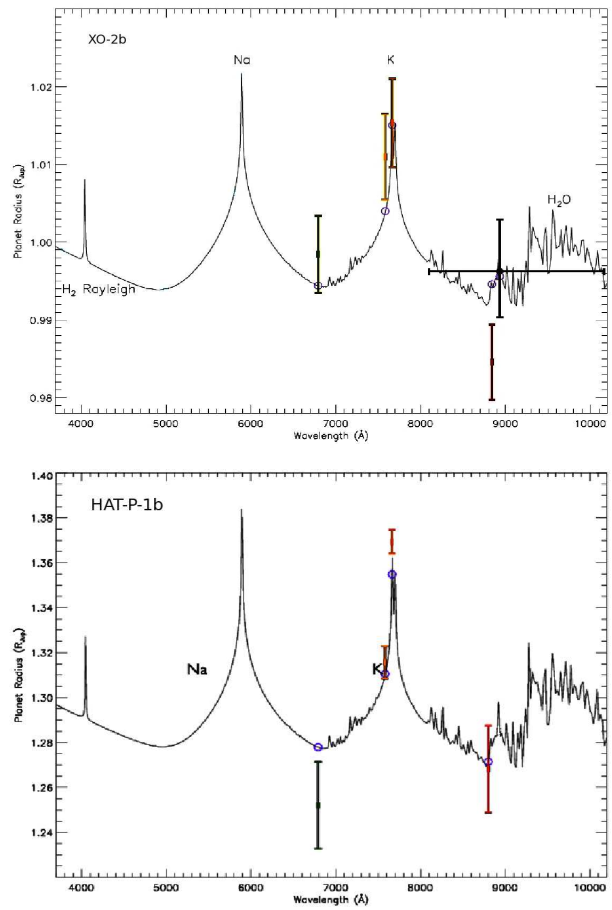

Fig. 2. Tunable filter planet radius observations of XO-2b (top) and HAT-P-1b (bottom). The solid line is the best fitting model. The purple open circles show the radius of the planet predicted by the models at the observed wavelengths. The points with errorbars are the GTC observations. The point on the XO-2b plot closest to 9000 Å corresponds to the radius observation of the planet by Fernandez et al. (2009).

of TrES-2b observed over a bin of 200 Å centered on the wavelengths indicated on the right. The systematics are caused by variable slit loses due to very bad seeing conditions (up to 4.5 arcsec), but the transit is clear observable in each wavelength bin.

In the case of the TF observations, K I absorption is clearly detected in both planets, as seen in Figure 2 (see also the Sing et al. (2011) result for XO-2b). In the case of HAT-P-1b, the K I absorption can only be reproduced by models that include a thermosphere linked to atmospheric scape.

REFERENCES

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