# TNG spectrophotometric measurements of HAT-P-1b

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We observed HAT-P-1 during the primary transit using the DOLORES spectrograph at TNG. The purpose was to study the transmission spectrum of the exoplanet by constructing multi-color transit lightcurves and deriving the variation of the transit depth as a function of wavelenght. We placed both the target and the bright companion star on the same slit to monitor simultaneously both objects and better control systematic effects. Here we present an overview of the results.

## Observations

Observations have been performed during two nights (August 14. 2012 and October 20, 2012) using the LRS-B grism and the DOLORES spectrograph. We used long-slit spectroscopy. The slit width was equal to 10 arcsec (4 Angstrom/pix) to reduce the chances of flux losses due to inaccurate pointing. We placed both objects on the slit and keep their positions fixed throughout the observations. The exposure time was set to 12 sec and the read-out was 45 sec. During the second night we achieved better performences windowing the detector which reduced the read-out to 20 sec. Overall we acquired 355 spectra during the first night and 811 during the second night.

## Data reduction

We first determined the centroid positions of the spectra fitting an analitic function along the spatial direction. The flux was then measured using aperture photometry setting a radius equal to 2.5 times the FWHM as measured in each spectral channel. The sky was determined from the outermost regions and subtracted. We constructed a master reference spectrum both for the target and the comparison star, and aligned all the spectra to the reference system of the master spectra using bicubic spline interpolation. We finally summed the flux of the target and the comparison star over a given spectral region, divided the first to the second and normalized the resulting lightcurve to the mean average of the out of transit measurements. We considered 6 different spectral Interval around 200 px wide in the dispersion direction.

## Data analysis

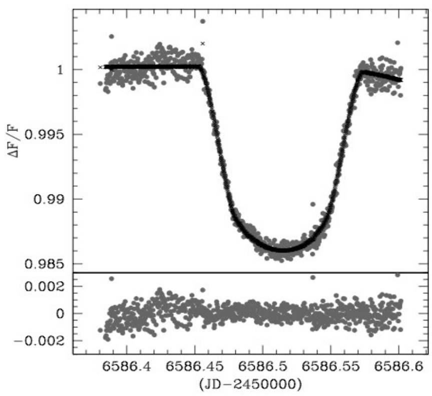


Fig. 1 – The white lightcurve

We first constructed a white lightcurve by summing the flux of the two objects over the entire spectral interval (Fig. 1). The RMS scatter of the white lightcurve is 630 ppm around 4.5 times larger than the theoretical photon noise. We adopted Mandel-Agol (2002, ApJ, 580, 171) algorithm to fit the transit, but considered also a linear dependence of the flux on the airmass, and the x and y shifts of the spectra. After fitting the white lightcurve we fixed the time of transit center, the density of the star and the duration of the transit and fit the multi-color lightcurves considering as free parameters the planet to star radius ratio, the linear limb darkening coefficient, the airmass and x, y shift coefficients and a constant. The uncertainties on the final parameters were estimated using bootstrap analysis.

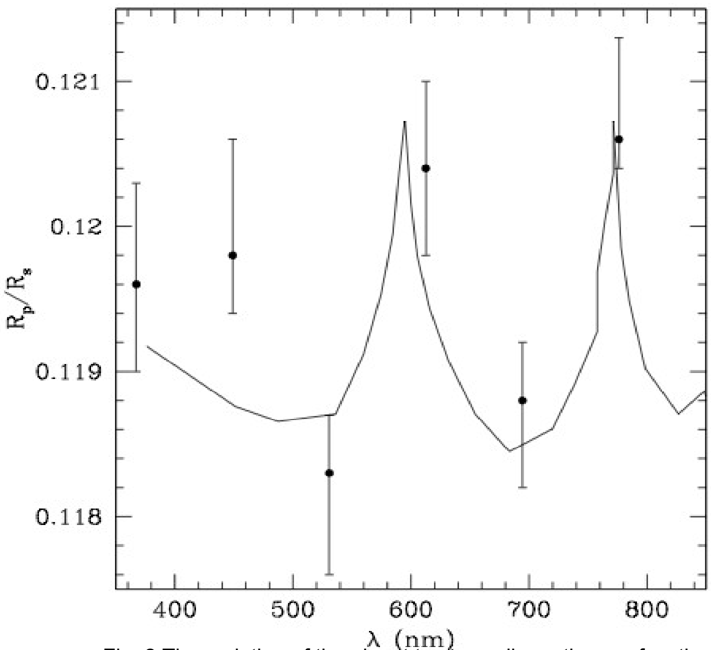


Fig. 2 The variation of the planet to star radius ratio as a function of wavelenght as obtained from our second night observations.

Fig. 2 shows the measured values of the planet to star radius ratio as a function of wavelenght. We overplot the models of Fortney et al. (2010, ApJ, 709, 1396) relative to a gravitational acceleration of 10 m $s^{-2}$ and 1000 K of temperature at the terminator. The two peaks denote the expected position and amplitudes of the alkali metals absorption features (Na on the left and K on the right).