A new look at NICMOS transmission spectroscopy of HD 189733: no conclusive evidence for molecular features

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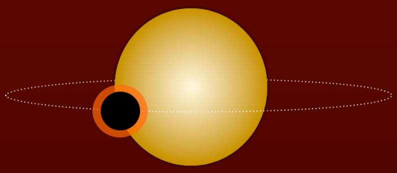
Based on the paper astro-ph/



INTRODUCTION

Transmission spectroscopy is a technique used to measure the wavelength dependence of transiting planets' radii. Typically, transit light curves are modelled assuming the planet as an opaque disk, with its size defined by the altitude at which the atmosphere becomes opaque to starlight (e.g. Seager & Sasselov 2000; Brown 2001). However, the optical depth in an atmosphere is wavelength dependent, being sensitive to atomic and molecular absorption. Thus, transmission spectroscopy is a direct probe of the composition of a planet's atmosphere.

Here, we present a re-analysis of archival HST/NICMOS infrared transmission spectroscopy of the exoplanet system, HD 189733, first presented in Swain et al. (2008, hereafter S08). This covered the wavelength range ~1.4-2.5μm, with detections of H_20 and CH_4 claimed. However, NICMOS grism spectroscopy suffers from considerable systematics (often larger than the expected atmospheric signal) that must be removed if we are to detect molecular features.

This poster presents a very brief summary of Gibson et al. (2010), in which we argue that the methods used to remove the systematics are not reliable, and therefore we do not think the detection of molecular species reported for HD 189733 by S08 is conclusive.

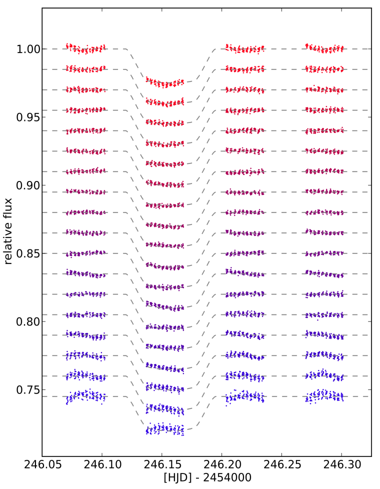


Fig. 1: Raw light curves for the 18 wavelength channels extracted from the NICMOS spectra. Time correlated systematics are present in all light curves, at a level greater than the transmission signal, which must be removed to obtain the transmission spectrum.

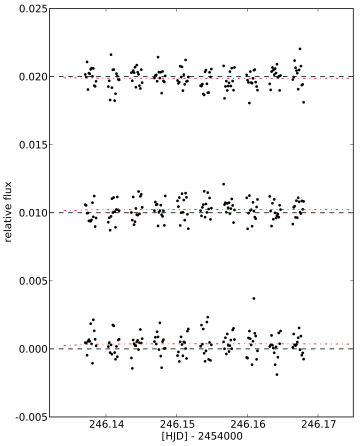


Fig. 2: Residuals from a constant radius model for the in-transit orbit for three of the wavelength channels after decorrelating using the baseline function; 2.41, 2.07 and 1.66 μm from top to bottom, respectively. The dashed red line shows the difference from the measured signal to the constant radius model. It is clear that systematic noise larger than the transmission signal remain.

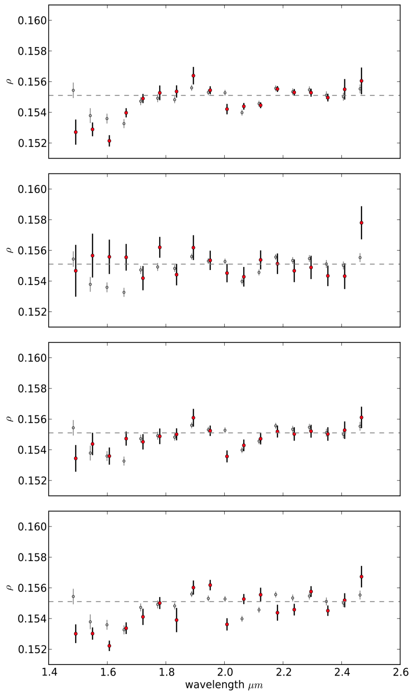


Fig. 3: Transmission spectra generated for HD 189733. The top plot shows the spectra generated following the methods of S08. The second shows where we have excluded the final orbit from the decorrelation procedure. The third plot is when we use a quadratic model for the baseline function, and the final plot is when we exclude the angle parameter from the baseline model. The data from S08 are plotted in grey. None of the features reported in S08 are present in all spectra.

DATA AND ANALYSIS

The data consist of 638 spectra, split into five half-orbits of HST. Light curves were extracted for 18 independent wavelength channels from 1.4 to 2.5μm (Fig. 1), each of which contains significant systematic noise. We first tried to remove these systematics by constructing a multi-linear model of the baseline function (i.e. how the measured light curve of the star would behave in the absence of a planetary transit) using the same method as S08, from the position of the spectral trace on the detector, its temperature, and the orbital phase of the HST, and correcting the light curve using this function.

The transmission spectrum is then found by fitting each light curve for the planet-to-star radius ratio (Fig. 3), where we are able to more-or-less recreate the spectrum from S08. We find that *the linear baseline model does not provide a satisfactory correction for systematics in the light curves*[1], as the residuals from the best fit model still show systematic noise above the level of variations in the transmission spectrum (Fig. 2).

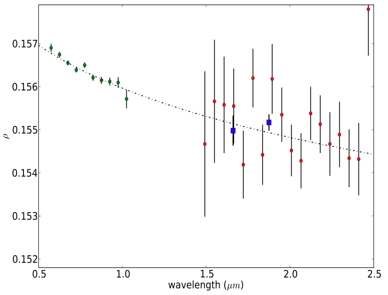


Fig. 4: Transmission spectrum for HD 189733 showing the NICMOS data excluding the final orbit from the decorrelation process (red), the optical ACS data from Pont et al. (2008, green), and broadband photometric measurements from Sing et al. (2009, blue). Using this reduction, the data may still be consistent with the haze interpretation, marked by the dotted-dashed line.

To determine uncertainties, we used a residual permutation algorithm, which should take into account how errors in the determination of the baseline flux project onto the the transmission spectrum. This provides larger uncertainties, and thus reduces the significance of detected molecular features. However, *we do not think the residual permutation model fully accounts for uncertainties in offsets between the flux levels in the orbits*, as these would be fitted for by the light curve model. We test the robustness of the transmission spectrum by modelling the baseline flux using varying methods.

Fig. 3 shows the transmission spectra produced using three slightly different techniques; excluding the final orbit from the decorrelation process, using a quadratic model for the baseline function, and finally excluding the angle from the fitting process. It is clear *that the same features do not appear in all four spectra.* Given we cannot choose which of the models best describes the baseline function, we cannot consider the top spectrum a robust detection of molecular species in HD 189733. In fact, the transmission spectrum may still be in agreement with the optical haze measured by Pont et al. (2008) using HST/ACS (see Fig. 4).

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[1] Note we also included the channel to channel correction from S08.