NUV RADII OF THE EXTRASOLAR PLANET HD 209458B

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Abstract.

Extrasolar planetary transits are powerful tools to probe their atmosphere and thus extract key physical properties of planets, like their mean densities, chemical compositions, or atmospheric structures. Every 3.5 days, the transits of the gaseous planet orbiting HD 209458 offer the opportunity to investigate the spectral features of its atmosphere. We present here NUV transmission spectroscopy of the transiting extrasolar planet HD209458b using HST/ACS. We present the data analysis of the seven HST orbits which were used to observe two transits of HD209458b. We found a radius of $R_P = 1.4\ R_{jup} +/- 0.05$ consistent with previous measurements. Due to various systematics, the radius of the planet in the NUV cannot be extracted with a high precison.

1 Introduction

In the case of HD 209458b, absorptions of several percents for H I Lyman-α, O I and C II have been measured in the hydrodynamically escaping upper atmosphere (Vidal-Madjar 2003, 2004, 2008, Désert et al. 2004, Lecavelier Des Etangs 2007, Ehrenreich et al. 2008) and a hot layer of hydrogen have been detected (Ballester et al. 2007). More recently, Rayleigh scattering by H_2 molecules has been identified (Lecavelier et al. 2008b) from sets of HST/STIS observations (Charbonneau et al. 2002, Knutson et al. 2007, Sing et al. 2008a,b). From the same datasets, the possible presence of TiO/VO as been studied (Désert et al. 2008).

2 Observations

The observing program was originally designed to observe HD 209458b with HST/STIS. After STIS failure, it has been possible to execute the program with HST/ACS during Cycle 13. The program (GO10145) consists in $3 + 2$ visits, performed with the ACS/HRC and the ACS/SBC. The results obtained using ACS/SBS with PR110L prism spectroscopy around the Lyman-α line are presented in a separated paper (Ehrenreich et la. 2008). The two other visits are composed of 7 orbits $(4 + 3)$. Each orbit was plan to be a sequence of direct image filters and prism PR200L spectra at various exposure times. The normal observing technique for all ACS-HRC PR200L spectroscopy is to obtain a direct image of the field followed by the dispersed prism image. This combination allows the wavelength calibration of individual target spectra by reference to the corresponding direct images. We obtain few exposures of 0.1s, 3.6 s, 40 s, and 540 s during the two transit observed. All the images were saturated.

3 Analysis

3.1 Slitless spectroscopy

HRC PR200L Slitless spectroscopy yields spectral 2D calibrated images. The spectral image is composed of the stellar halo surrounding the stellar center position, the red pile-up resulting from the built up of photons on a few detector pixels which appear when using a prism the saturation zone and the stellar continuum between 150 and 400 nm. The spectral resolution significantly diminishes toward the red. For bright objects, such as

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HD 209458, this effect can lead to blooming of the HRC CCD from filled wells; the overfilled pixels bleed in the detector Y direction. The tilt of the prism causes a deviation of about 300 pixels between the position of the direct object and the region of the dispersed spectrum on the CCD.

3.2 Spectra extraction

All the effect described previously make this extraction very difficult. We used the flat-fielded spectral images to extract the spectra. Since there is no slit in the ACS, the Point Spread Function of the target modulates the spectral resolution. The so called background is the sum of the effects of the real background, the halo, and the diffraction spikes. Due to the quasi central symmetry of the image, we considered that a good evaluation of the background was to consider the opposite pixels from the star. The current calibration of the wavelength solution used in the aXe data reduction software assumes the use of these apertures. At 3500 Å, the dispersion drops to 105 Å per pixel Lyman-$\alpha$and is 563 Å per pixel at 5000 Å.

3.3 Fitting the transit light curve

We parameterized the transit light curve with 4 variables: the planet-star radius ratio $R_p/R_\star$, the stellar radius to orbital radius ratio $a/R_\star$, the impact parameter b, and the time of mid-transit T_c0. We used the transit routine OCCULTNL developed by Mandel & Agol (2002) where limb-darkening corrections are taken into account. We then performed a least-squares fit to our data over the whole parameter space.

4 Results and conclusion

We extracted the NUV radius of HD 209458b at 2 bandpasses. We are able to detect the stellar MgII doublet at 2 800 Å. We found a radius of $R_P = 1.4\ R_{jup} +/-0.05$ in agreement with the radius of $1.3263\ R_{jup} +/-0.0018$ found in the visible (Knutson et al. 2007) obtain from STIS/HST observations.

Although ACS is very sensitive, the error bars derived here are large since they include various systematics that affect the determination of the radius of the planet. The telescope jitter, dithering and intra-pixel sensitivity variations are responsible for severe fluctuations observed in individual spectra. We conclude that dithering should not be used for precision photometry when levels of 0.01% are needed. Finally, the exposures were all saturated which introduce not linearity effects and thus make the comparison between consecutive wavelength difficult. The error bars we derived are to large to draw any firm conclusion on the detection of absorbers potentially present in the atmosphere and which could be observed in this wavelength domain.

COS will reach the domain of 1200-3000 Å. This domain include the ACS one but with a much better resolution and sensitivity, allowing the detection of supplementary absorber in this region.

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