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VLT Spectroscopy of HD209458b Transits

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Abstract. Following model predictions (Seager & Sasselov 2000; Brown 2001), the transmission spectrum of the transiting planet HD209458b should exhibit detectable alkali lines and molecular features in the optical and near-IR spectrum. This paper shows an attempt to detect HeI at 1.083 μm and optical signatures with the VLT.

1. Introduction

Since the discovery of HD209458b, the giant planet occulting its parent star as seen from Earth (Charbonneau et al. 2000; Charbonneau 2003), a large panel of follow-up observations has been proposed and performed to get some identification of the atmospheric components of the planet. So far the detection was only possible from space (NaI signature, Charbonneau et al. 2002) and other searches have been negative (Bundy & Marcy 2001; Moutou et al. 2001; Brown et al. 2002; Richardson et al. 2003). This paper presents the attempts performed on the VLT instruments during the last 2 years, both in the visible and near-infrared domains.

2. Observations

2.1. Optical Spectrum

One full transit has been observed with the echelle spectrograph UVES of the VLT in June 2000. A similar time was devoted to register a reference spectrum of HD209458 in the same setup, out of transit. With a 0.3" slit, the achieved resolution is above 100,000. The spectral domain is 328-668 nm with two small gaps. 25 individual spectra were acquired during the planet transit, each of them of signal-to-noise exceeding 400, especially in the red. The spectrum extraction from 2D echelle images was performed using IRAF scripts. An example of the UVES spectrum is shown and described in Figure 1.

Although the analysis of the rich spectrum of HD209458 is still ongoing, we report so far no detection. After the announcement of NaI detection by HST (Charbonneau et al. 2002), we investigated more carefully the spectral region around the NaI doublet, including with the same method as used by the authors of this detection (i.e., in broad bandwidths centered on the doublet lines and compared with ajacent bandwidths). However, spectra obtained from the ground are polluted by shallow telluric features in this spectral domain, showing variations with time of the order of a few percent, and this is mainly what we observe. Also, the UVES spectrum at 590 nm, in the configuration we used, shows a strong artifact (non linear pixels) which greatly limits any careful analysis.

More generally, it is probable that our spectrum, although of good quality, suffers from a lack of calibrations: first, the flat field accuracy could limit the achivable S/N in some sections, and second, repeated observations of a telluric standard would have been precious to monitor any change due to the Earth's atmosphere. During the short transit period (3 hours) any depointing to a comparison star seems a loss of precious transit time, but on the other hand, it is of first importance to get a precise measurement of telluric variations.

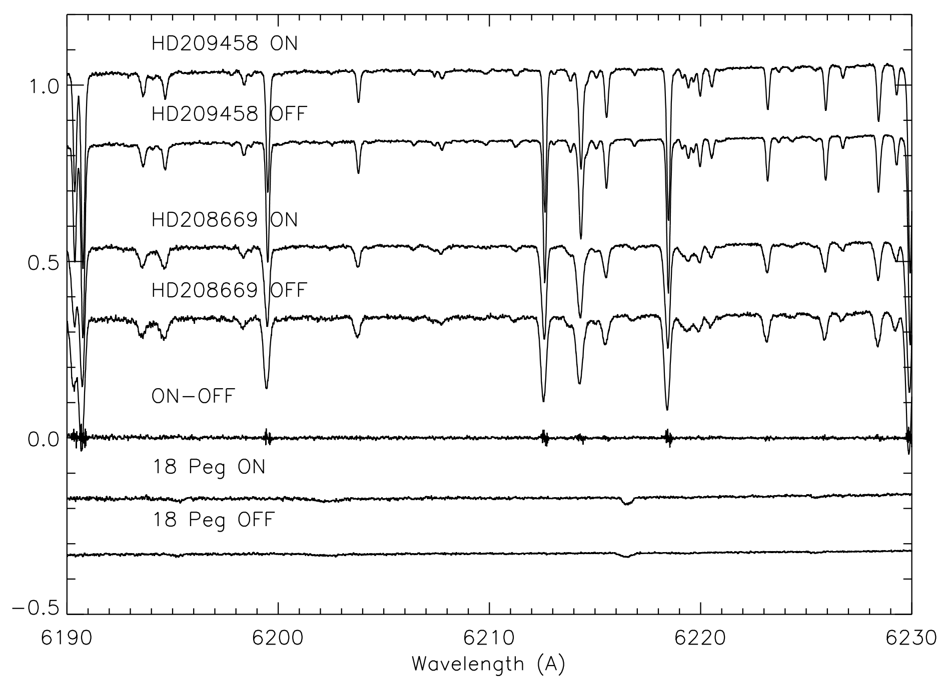

Figure 1. An example of the UVES spectra of HD209458 in transit and out of transit, and the comparison stars in the range 619–623 nm. From top to bottom: HD209458 on and off transit, a G type star (on, off) the on-off difference spectrum and a hot star (on, off).

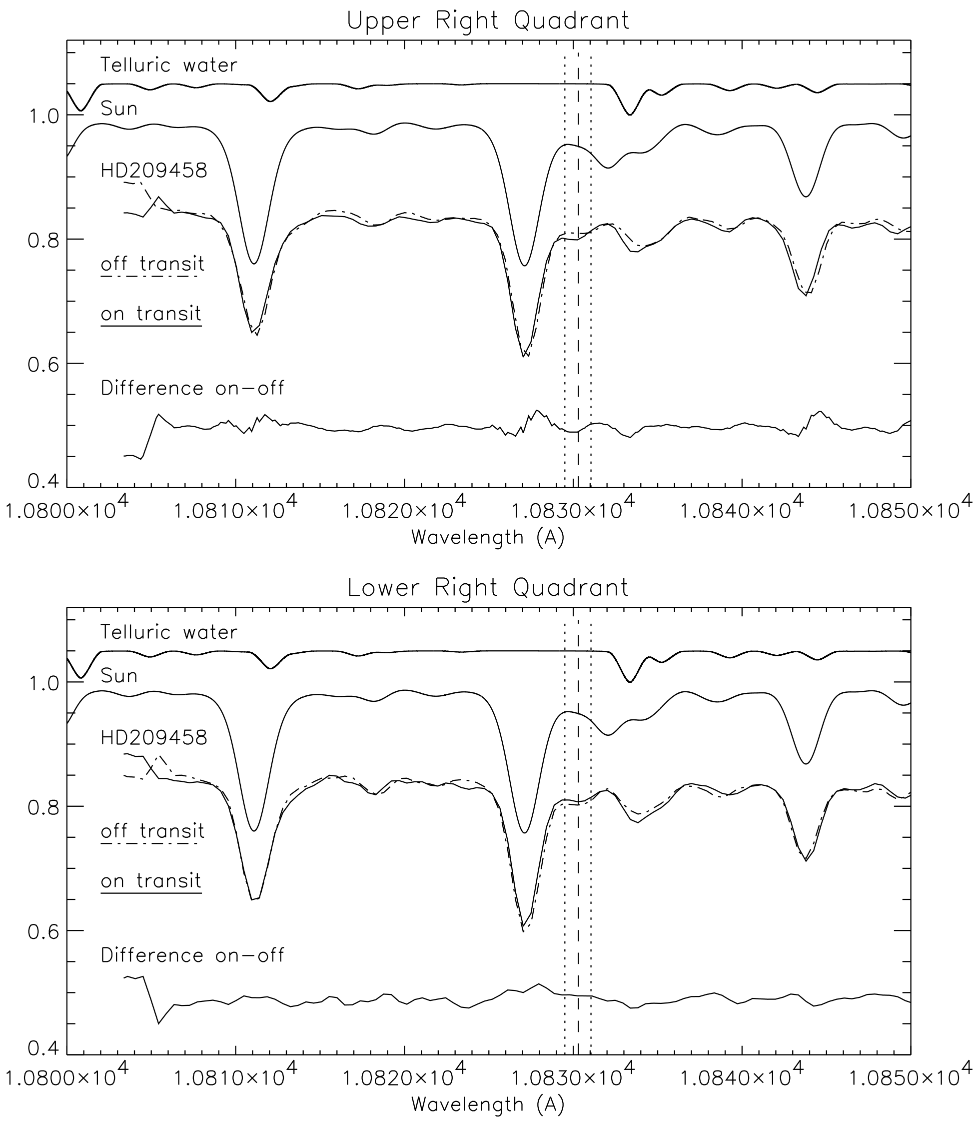

Figure 2. ISAAC spectra in the range 1.080–1.085 μm. The position of the expected HeI line is shown by the vertical lines. Together with the spectrum of HD209458 is plotted the solar spectrum and the calculated absorption spectrum of telluric water. Differentiation between the upper and lower sections of the detector is done, because a different filter has been applied for fringe removal.

2.2. Near-IR Spectrum

Another transit of HD209458b has been observed with the near-IR camera and spectrograph ISAAC on the VLT, in June 2001. The grating was centered around the expected HeI line at 1.083 μm. This line is predicted to be the strongest one of the optical and near-IR transmission spectrum of a close-in giant planet such as HD209458b (Seager & Sasselov 2000). The medium resolution mode of ISAAC is used with a 0.6" slit, offering a spectral resolution of 5,800 in the domain 1.06–1.1 μm. The raw spectrum shows strong pixel-to-pixel variations, attributed to an electronic "odd-even column effect"; its amplitude (4 to 6%) varies in each quadrant of the ISAAC Hawaii detector, which makes its removal quite difficult. Consequently, each quadrant was reduced separately. This had the effect of limiting the efficiency of sky background subtraction from the jittered images, but the star is so bright that the sky lines are hardly visible. Figure 2 shows the spectrum in the region of interest, during transit and out of transit. An absorption line of 2% central depth and 1.5Å width would have been detected at 1.083 μm.

More details on the spectra, data reduction and achieved sensitivity are given in a forthcoming paper (Moutou et al. 2003 in preparation).

3. Future Work

It seems that more observations in the optical at high resolution are required, with more care on calibration data. Additional transit data are being acquired this summer on VLT/UVES and should allow placing higher constraints on the line detectability. Maybe a confirmation of HST observations of NaI will be possible. When higher spectral resolution is available in the near-infrared (e.g., CRIRES on the VLT), the observation of molecular absorptions from the ground will be feasible; band blending is currently limiting the detection. Many other attempts to detect HD209458b's atmosphere are in progress by several groups (Richardson et al. 2003; Brown et al. 2002; Harrington et al. 2003).

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