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The 0.81 – 4.2 micron ground-based transmission spectra of the hot jupiter HD-189733b

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Abstract

We present ground based transmission spectroscopy of the hot jupiter HD-189733b using the SpeX instrument on the NASA Infrared Telescope Facility. We obtained two nights of observation of the primary transit for the z, J, H band and two nights for the K, L band. The data, acquired simultaneously over each night, cover a total spectral range from 0.81 to 4.2 micron. We analysed our data using techniques explained in previous publications from our team ([23],[25]), probing the statistical significance of our results. Furthermore we compared our results with simulated atmospheric spectra and we discussed the outcome in the light of previous results published in the literature. Our observed spectra are consistent with previous data recorded from space in the bands where there is an overlap, showing that low resolution exoplanet spectroscopy is feasible with medium-sized telescopes on the ground (Danielski et al, submitted.).

1. Introduction

With over 700 exoplanets already discovered and many more exoplanet discoveries expected in the near future, research in this area has gained steadily in prominence. Thanks to the outstanding new data the *Kepler* mission ([4],[5]) is providing, the menagerie of exoplanets is getting more diverse and the smallest exoplanet known today is Mars-sized ([16]). Beyond the planet-star system key parameters already obtainable, such as mass, radius and orbit inclination, the characterisation of the atmosphere of exoplanets is the next critical step to acquire a deeper knowledge of these far-away worlds. The ability to detect planetary atmosphere features, which have a contrast of only about 10^{-4} compared to the host star radiation, is quite a challenge. However, for exoplanets whose orbits are aligned so that they cross the surface of the mother star when viewed from the Earth, this has proved to be feasible. We can do this by measuring the dip in the stellar lightcurve when the planet transits in front of the star (or disappears behind it) and then repeating the measurements at different wavelengths. With the high stability of Spitzer Space Telescope and Hubble Space Telescope the spectra of bright close-in massive planets could be obtained and molecular species like water vapour, methane, carbon monoxide and dioxide could be detected. On the positive note, the new Wide Field Camera 3 on Hubble is already delivering novel superb results ([3]). Unfortunately with the loss of cold Spitzer and NICMOS, the wavelength range covered from space has narrowed, hampering the ability to further reduce the degeneracy in the interpretation of the spectra. While in the past years the transit technique, combined with the photometric precision of Hubble and Spitzer, has been an asset for the success of this field, a few debates in the community have originated from the impossibility of repeating earlier observations beyond any reasonable doubt (e.g., [8], [18], [9]). Most of these concerns have been addressed by adopting more robust statistical techniques to remove instrumental systematics ([11],[10], [25],[26]). Furthermore over the last few years there has been a rapid escalation in ground-breaking results ([17],[19],[20], [6],[23], [25]). Ground-based observations have the non-trivial limitations of having telluric contamination interfering with the measurements, especially in the infrared where most of the key molecules show stronger absorption features. However, observations from the ground can be repeated more easily and in some cases they can cover spectral regions no longer reachable from space.

The hot Jupiter HD-189733b has been the most observed planet to date due to the brightness of its mother star and its favourable atmosphere. Observations, taken with multiple instruments and by different teams, have suggested the presence of water vapour, methane, CO_2 and CO in its atmosphere (e.g., [13], [24],[2], [7], [12], [21], [22]). The most recent detection of non-thermal emission in its dayside, related to the 3.3μm methane feature ([23], [25]), has increased the interest towards this object even further ([15]).

2. Summary and Conclusions

Here we present new observations of HD-189733b from 0.81 to 4.2 micron with the NASA Infrared Telescope Facility (IRTF)/SpeX instrument. From these observations for the first time we could extract ground-based transmission spectra of HD-189733b and compare the results with simulated atmospheric spectra. We discuss the outcome in the light of previous results obtained from space in the same wavelength region. The nights were good enough to allow the extraction of low resolution spectra in z, J, H and K, L bands. On top of that, given that z, J, H and K, L bands were observed simultaneously, these measurements have a non trivial advantage over photometric data recorded at different dates ([18]): the activity of the star ([13], [14]) in fact could prevent the level of accuracy we need for the detection of molecular features in the planetary atmosphere ([1]). Here we have used the technique described in [23]) tailored for transmission spectroscopy and preceded by an accurate cleaning process, testing then the statistical significance of our results.

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