

Water in the Atmospheres of Hot Jupiter Exoplanets

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ABSTRACT:

We present HST WFC3 transmission spectra for three hot Jupiters using the G141 low-resolution grism. We find evidence for water absorption in the upper atmosphere of HAT-P-1b and WASP-17b, with a significant cloud deck observed in the spectra of WASP-31b.

This demonstrates an example of atmospheric diversity in similar worlds.

OBSERVATIONS:

We conducted single transit observations of three hot Jupiter exoplanets using HST/WFC3 in the near-IR from 1.1-1.7 μ m. HAT-P-1b and WASP-31b were observed in the newly available spatial scan mode as part of program GO 12473 (D.K. Sing, 2012)^{a,b,c,d,e}, while WASP-17b was observed in staring mode as part of GO 12181 (D. Deming, 2011)^f.

ANALYSIS:

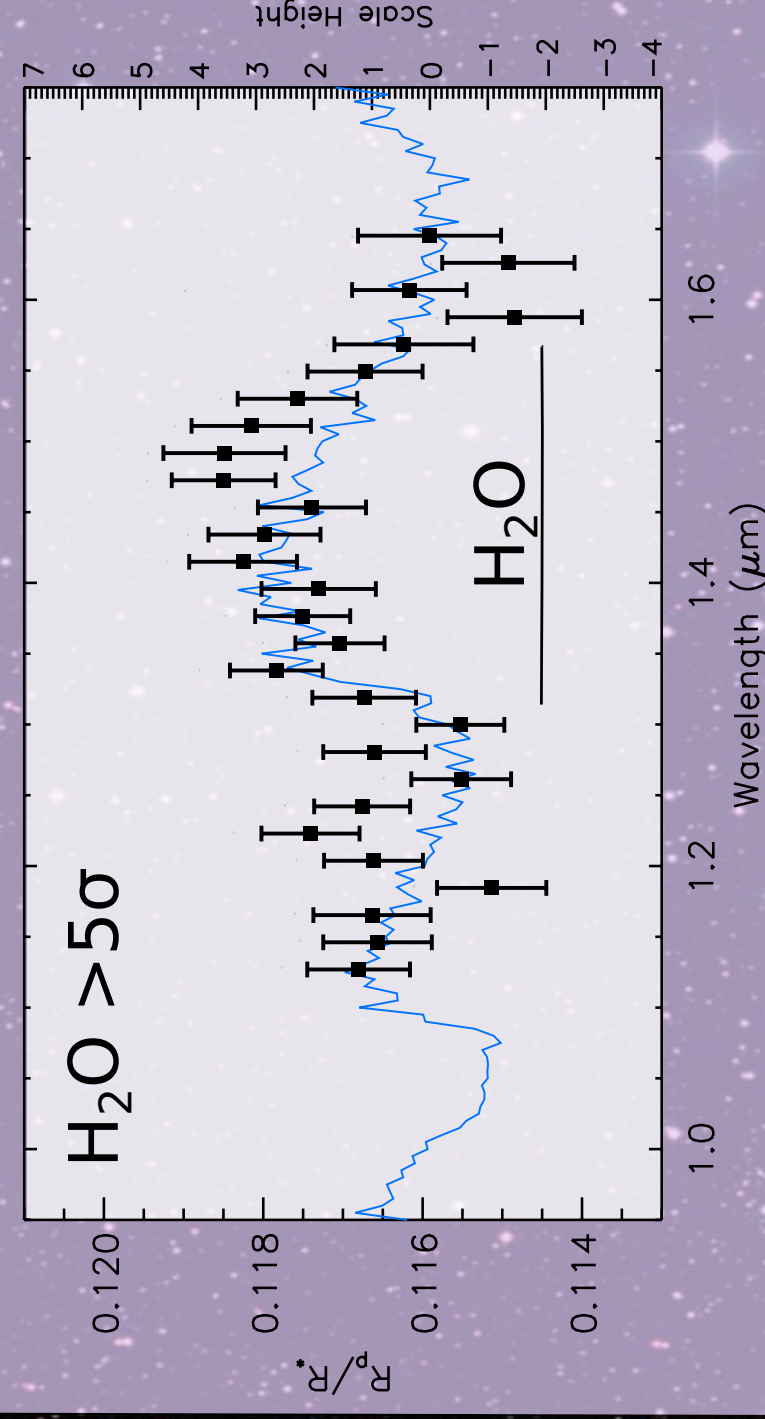
We use custom routines to extract the spectra from each exposure and conducted white light analysis on each transit to determine a wavelength independent systematic model as well as individual parameter fitting for each wavelength channel. The main systematic is that of HST's thermal changes along its orbit which we fit with a polynomial to HST phase with the order determined by reducing the BIC in the white light fit.

HAT-P-1b

ORBIT 4.5d
RADIUS 1.242R_J
MASS 0.531M_J
TEMPERATURE 1305K
SCALE HEIGHT 634km
ATMOSPHERE Na, H₂O

HAT-P-1b is a low density hot Jupiter orbiting a single member of a G0/G0 visual binary with a separation of 11".

A transmission spectrum was constructed using differential photometry and bins 192 Å wide with precisions of 690 ppm on average per wavelength channel. We then compared this to a series of atmospheric models. We find evidence for H₂O absorption in the atmosphere at 1.4 μ m with a >5 σ significance level, with models in favour of a cooler planetary-averaged T-P profile at mbar pressures near the limb of the planet^a.

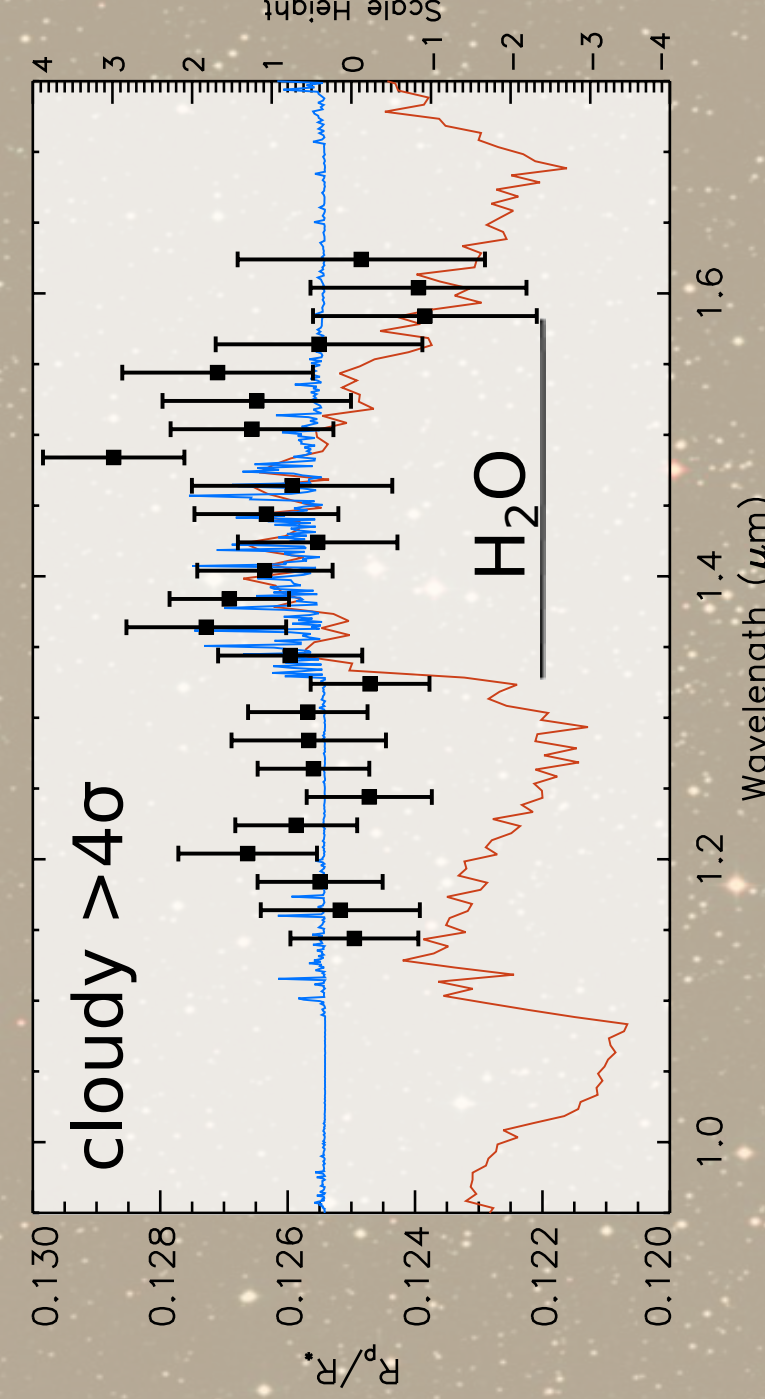


WASP-31b

ORBIT 3.4d
RADIUS 1.590R_J
MASS 0.480M_J
TEMPERATURE 1568K
SCALE HEIGHT 1247km
ATMOSPHERE Clouds, K

WASP-31b is a low density hot Jupiter orbiting a metal poor late F-type dwarf star in a well aligned system.

A transmission spectrum was constructed using bins 200 Å wide with precisions of 1217 ppm on average per wavelength channel. We compared this to a series of isothermal models with unobscured water features and partly cloudy models with rayleigh scattering. We find evidence for a cloudy atmosphere with a significantly muted water feature with a fit of 1.8 σ over that of a flat featureless atmosphere^e.



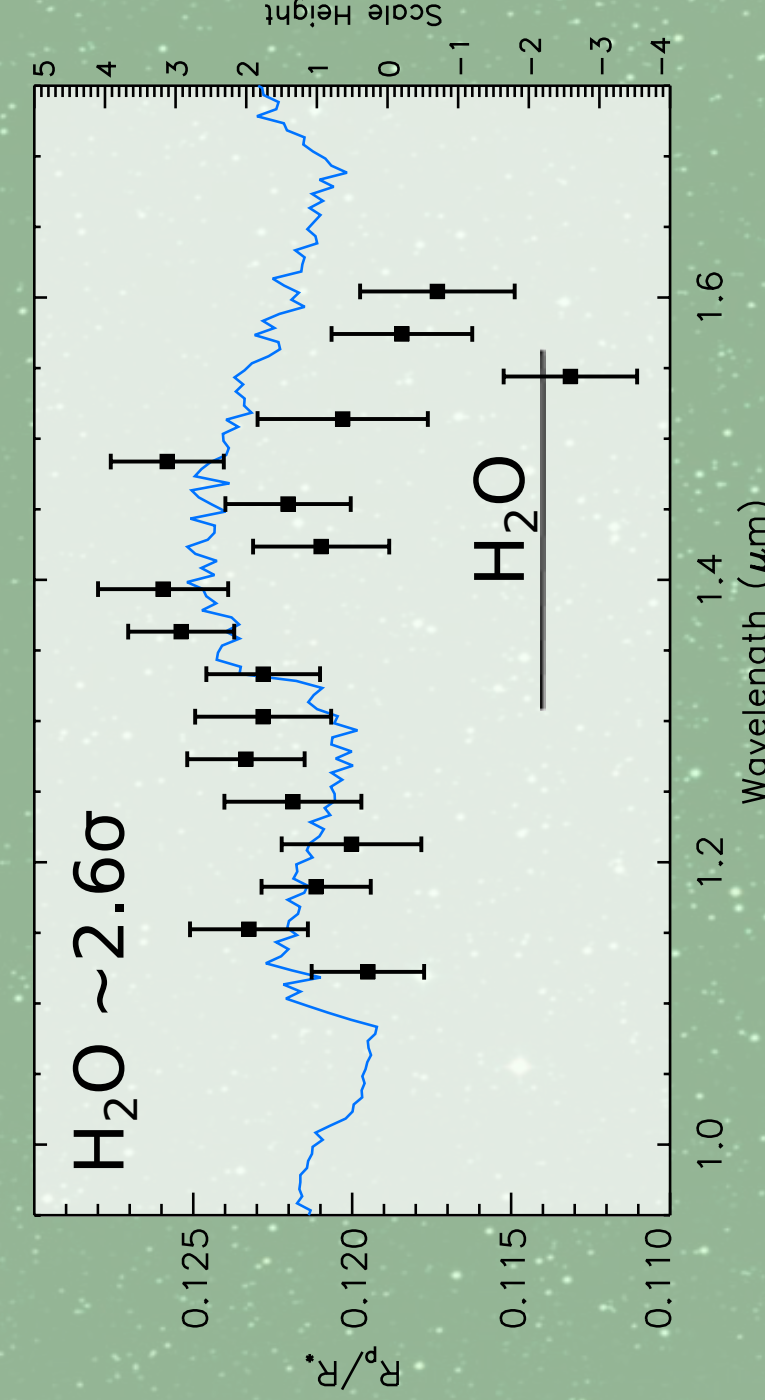
WASP-17b

ORBIT 3.735d
RADIUS 1.932R_J
MASS 0.477M_J
TEMPERATURE 1773K
SCALE HEIGHT 2035km
ATMOSPHERE Na, H₂O

WASP-17b is a low density hot Jupiter in a retrograde orbit compared to the rotation of the host F-type star.

A transmission spectrum was constructed using bins 370 Å wide with an average precision of 2029 ppm per wavelength channel. This work is a re-analysis of A. Mandell et al. 2013^f which identified this feature as potential H₂O absorption in the upper atmosphere. We compared this work to

T_{eff} = 1500 K isothermal atmospheric models and found a 2.6 σ significance of fit over a flat featureless atmosphere.



REFERENCES:

- ^a HR Wakeford et al. 2013, MNRAS, 435, 4
^b C Huitson et al. 2013, MNRAS, 434, 4
^c N Nikolov et al. 2014, MNRAS, 437, 1
^d DK Sing et al. 2013, ApJ, 779, 128
^e DK Sing, HR Wakeford et al. in prep
^f A Mandell et al. 2013, ApJ, 779, 128

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IMAGE CREDIT:

- HAT-P-1b (NASA/JPL-Caltech);
WASP-31b (cfa.harvard);
WASP-17b (NASA)



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