Clouds on Ultra-hot Jupiter HAT-P-7b

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10x further to the orbital distance of Mercury

HAT-P-7b

Exoplanets

Defined as a planet orbiting any star other than the Sun. First discovered in 1995, now over 4000 known.

Ultra-hot Jupiters

Planets roughly the mass of Jupiter, orbiting so close to their host star that they are 'tidally locked' (one side always faces the star). This 'day-side' can reach temperatures of ~3000 K. The 'night-side' is cooler, at ~500 K.

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Planet Properties

Planet Mass: 1.74 M_{Jup}

Planet Radius: 1.43 R_{Jup}

Orbital Period: 2.20 days

Orbital Distance: 0.0379 AU

Acknowledgements

This poster contains work from a collaboration started at the Cloud Academy conference (2018). Contributing authors are:

Alam, M. K.; Corrales, L.; Helling, Ch.; Herbort, O.; Iro, N.; Lew, B.; MacDonald, R. J.; Molaverdikhani, K.; Ohno, K.; Parmentier, V.; Steinrueck, M.; Woitke, P.; Worters, M.

Stellar Properties

Spectral Type: F8V

Stellar Mass: 1.5 M_{Sun}

Stellar Radius: 2.0 R_{Sun}

Not to Scale

Day-side and Night-side Temperatures

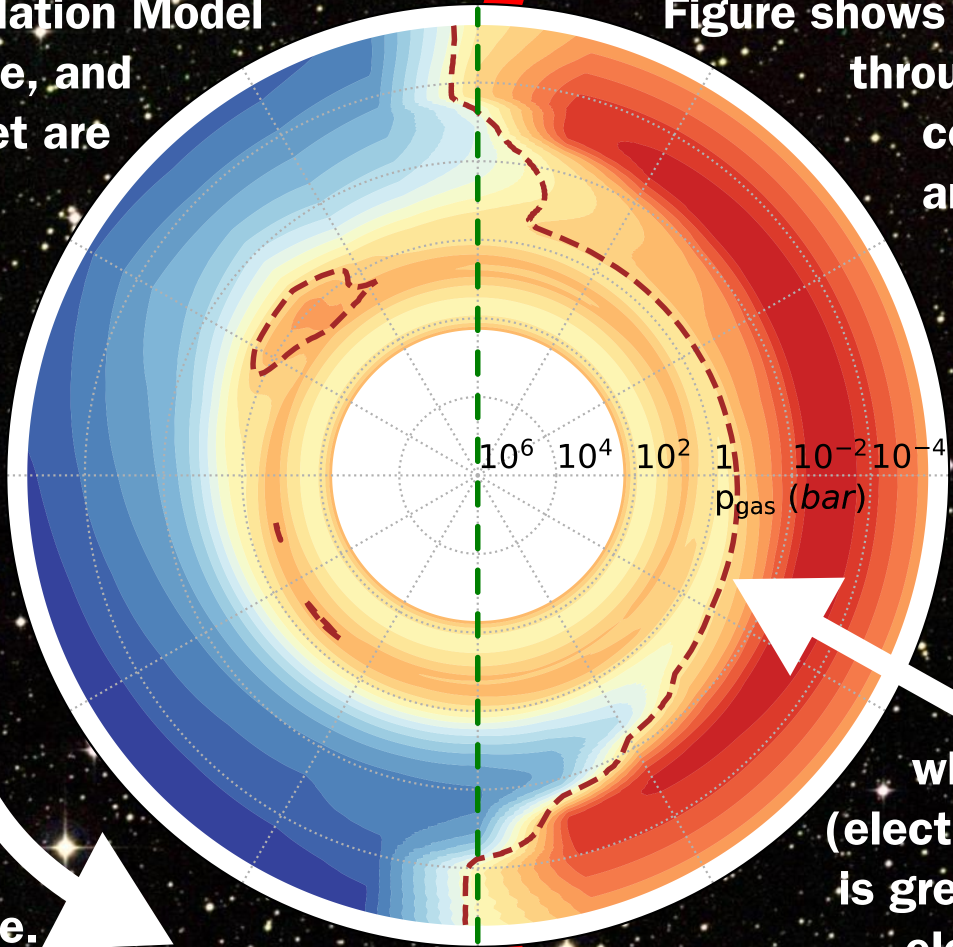
To Observer ← → **To Star**

Evening Terminator

Data from a 3D Global Circulation Model for the temperature, pressure, and wind speed around the planet are used as input to our cloud formation model [1].

Figure shows temperatures around a slice through the planet's equator, the central region is not modelled and is not to scale. The green line shows the separation between day-/night-side called the 'terminator'.

Anti-stellar Point

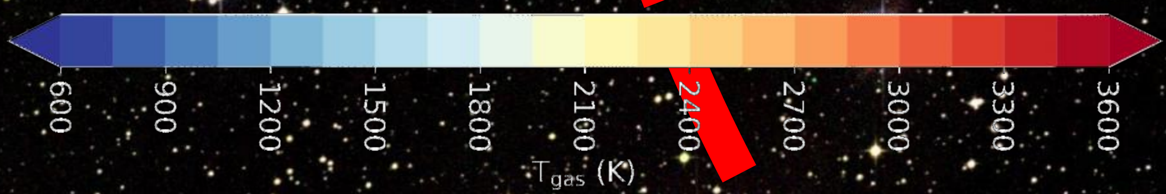


Sub-stellar Point

Tidal locking causes the planet to rotate this way. Winds also go in this direction, so cold gas is transported to the day-side.

Brown dashed line shows where the degree of ionisation (electron pressure/total pressure) is greater than 10^{-7}. In this region electrostatic behaviours affect local atmospheric conditions [2].

Morning Terminator



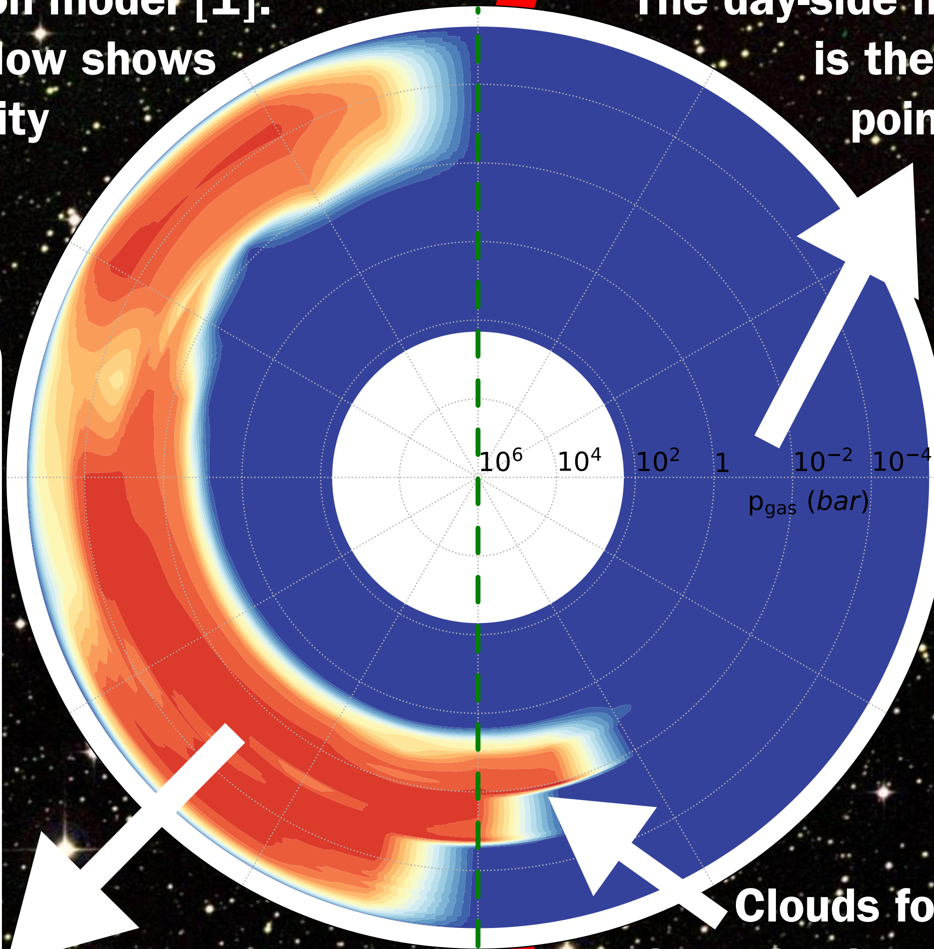
Clouds Form Mostly on the Night-side

To Observer ← → **To Star**

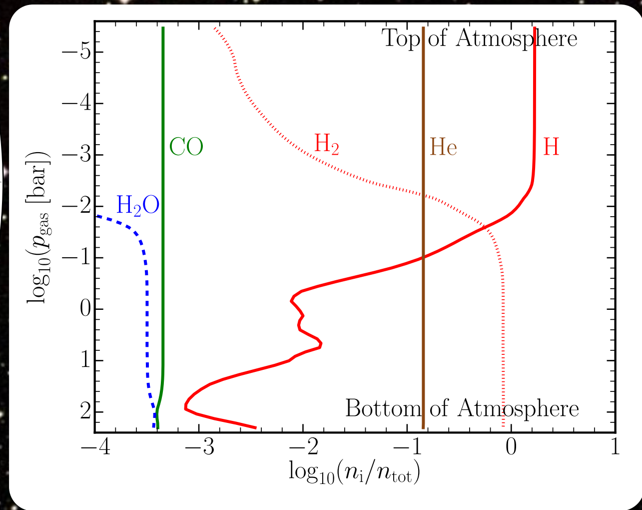
Results of the cloud formation model [1]. Figure setup as previously. Now shows the ratio of cloud mass density to local gas mass density:

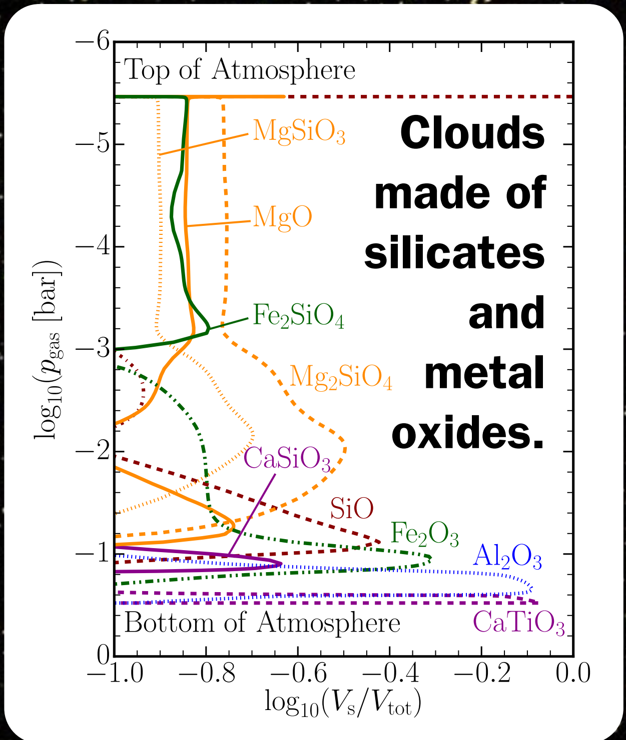
Red = maximum clouds

Blue = no clouds.



The day-side has (almost) no clouds, below is the gas phase for the sub-stellar point. High temperatures destroy H_2 and H_2O at the top of the atmosphere.

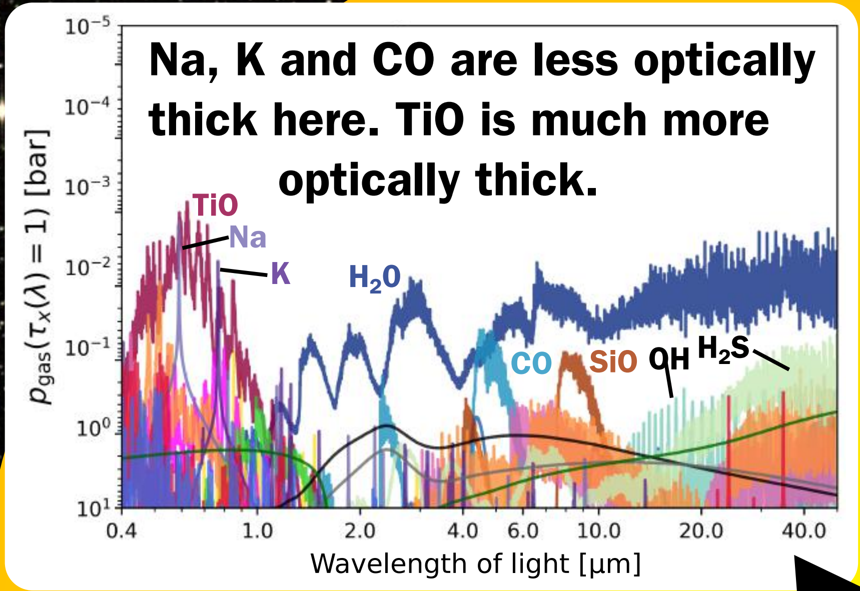




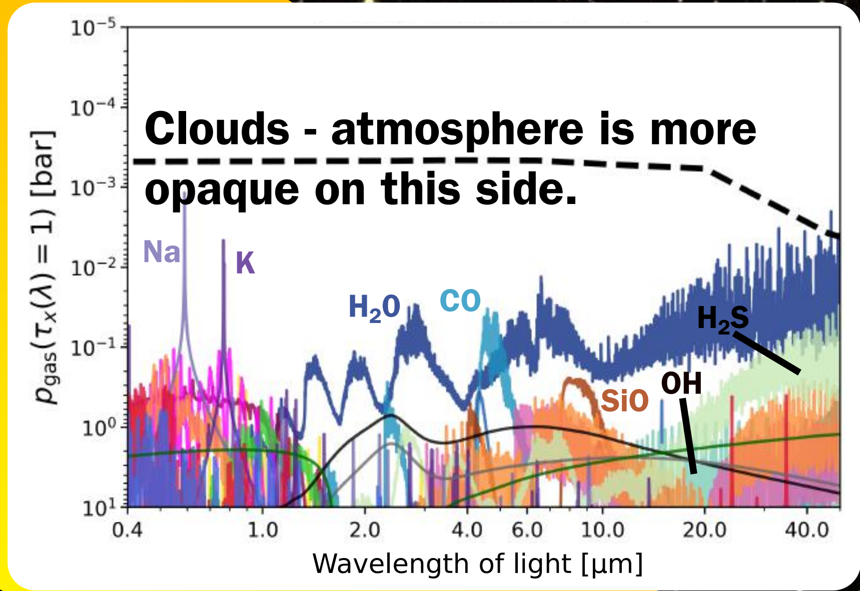
Volume fractions of main cloud materials for the anti-stellar point.

Clouds form at the morning terminator and nearby day-side, deep in the atmosphere. Here cool gas has been blown over from the night-side.

How HAT-P-7b Looks in Observations

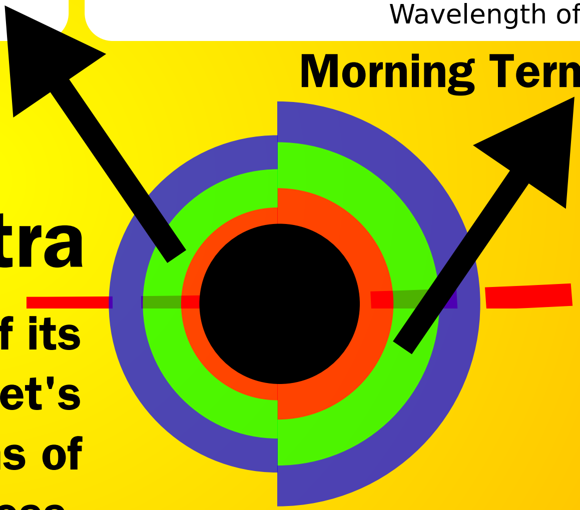


Evening Terminator



Morning Terminator

Y-axis shows the pressure where the gases and clouds become 'optically thick' (light does not go any further). Only clouds and the most important gases, are labelled.



Transit Spectra

As the planet passes in front of its star, light shines through the planet's atmosphere, different wavelengths of light are absorbed more or less. Thus the planet appears bigger or smaller depending on the wavelength observed.

The dramatic temperature change between HAT-P-7b's day-/night-side affects where clouds form on the planet. The day-side atmosphere is also partially ionised because of the high temperature. Such differences also affect the terminators, and this asymmetry should be observable with upcoming instruments [1].

Not to Scale

References

[1] Helling, Ch.; Iro, N.; Corrales, L. et al. 2019, A&A, 631, A79
[2] Helling, Ch.; Worters, M.; Samra, D. et al. (in prep)