Constraining the Atmospheric Composition of WASP-18b

Constraining the Atmospheric Composition of WASP-18b

Robert Wells1,2, Mercedes Lopez-Morales2, Nikole Lewis3 and the ACCESS collaboration4

1. University of Southampton (UK), 2. Harvard-Smithsonian CfA, 3. STScI, 4. U. of Arizona, Pontificia Universidad Catolica (Chile), Carnegie Institution for Science, U. of California Santa Cruz, U. of Maryland, Max Planck Institute for Astronomy (Germany)

Abstract

The goal of this work is to constrain the composition of the atmosphere of the hot Jupiter WASP-18b by comparing transmission spectroscopy data to theoretical models; and to advance our knowledge of atmospheric processes such as cloud formation and thermal inversion layers. We collected optical transmission spectra of WASP-18b via multi-object spectroscopy with wide slits, using IMACS on the Magellan telescopes at the Las Campanas Observatory, Chile. We are searching for TiO in the atmosphere of WASP-18b to study thermal inversions and/or hazes and what causes them. Our work is part of ACCESS (the Arizona-CfA-Católica Exoplanet Spectroscopy Survey), which is a project to create the first comprehensive database of optical exoplanet spectra, using ground based facilities. ACCESS will contribute to comparative studies of exoplanets over a wide range of radii, masses and temperatures; and allow us to refine models of exoplanet chemical, radiative and dynamical processes.

Introduction

Thermal inversions have been found in exoplanets much like the ozone layer in Earth’s upper atmosphere where O3 is formed and photodissociated causing a large temperature increase in that region.

However for hot Jupiter exoplanets the temperature is much too high for thermal inversions to be caused by oxygen. These thermal inversions have been attributed to TiO and VO in gas form which are strong absorbers in the optical. TiO and VO are theorised to be strong absorbers in the atmospheres of hot Jupiters, by analogy to atmospheric processes in low-mass stars. However, those compounds have not been detected in the atmospheres of hot Jupiters yet.

In this work we are searching for the presence of TiO in the atmosphere of the hot Jupiter WASP-18b, using optical transmission spectroscopy of its atmosphere.

**WASP-18b**

- Discovered in 2009 by Hellier et al. (2009)
- Spectra sensitive to TiO in atmosphere
- Large star-planet interaction
- Near zero albedo – hint of a clear atmosphere?
- Largest temperature in the ACCESS sample
- Almost no redistribution of energy from day to night side
  - Non-isothermal, non-blackbody profile – thermal inversion layer?
- In late stages of spiralling in towards its host star

**Preliminary results**

**Method**

- Data taken using IMACS on Magellan Baade Telescope
  - 3 primary transits collected between Aug 17 and Nov 7, 2014
  - Optical transmission spectra (4,000–10,500Å)
  - Multi-object spectroscopy with wide slits to get simultaneous spectra of WASP-18 and five comparison stars
- Data reduction done with ACCESS pipeline
- Systematics of white light curves removed using our own implementation of the Sys-Rem algorithm

**Future work**

The data will be binned according to wavelength and each bin detrended separately using Sys-Rem. Then we will create a plot of planetary radius over stellar radius against wavelength using the equation below, along with atmospheric models produced by ACCESS member Nikole Lewis.

\[
\Delta F = F_{\text{out}} - F_{\text{in}} = \frac{R_p}{\sqrt{R_*}}
\]

An example of this is presented below from a paper by members of the ACCESS collaboration on the hot Jupiter WASP-6b (Jordán et al. 2013), showing clear scattering i.e. clouds.

**References**