On the use of the chromatic Rossiter-McLaughlin effect to measure the Rayleigh scattering on HD189733b

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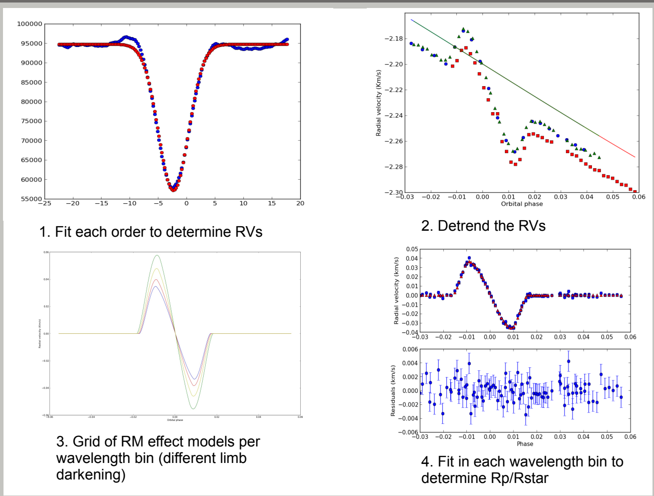
Introduction

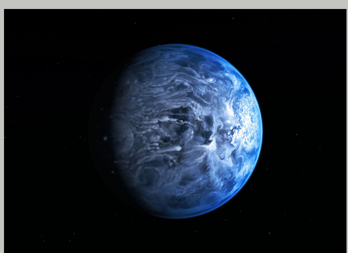
- Transmission spectroscopy is a powerful technique to probe the atmospheres of exoplanets
  - requires high-precision spectrophotometry
  - mainly successful from space
- Detection of atmospheric haze, causing Rayleigh scattering, on HD189733b (Pont et al. 2008, Sing et al. 2011)
- We **propose a technique that makes use of the Rossiter-McLaughlin (RM) effect** (based on Snellen 2004):
  - depends only on the differences in the profiles of the stellar spectral lines in same on-transit spectra (no comparison between on- and off- transit spectra)
  - less likely to be influenced by systematic effects

The method



1. Fit each order to determine RVs
2. Detrend the RVs
3. Grid of RM effect models per wavelength bin (different limb darkening)
4. Fit in each wavelength bin to determine Rp/Rstar

Conclusions



NASA, ESA, M. Kornmesser http://spacetelescope.org/images/heic1312a/

- Featureless spectrum of HD189733b
- consistent with **Rayleigh scattering** in the atmosphere
- from the scattering law

$$\mathrm{R_p} = \alpha \mathrm{H} \ln\lambda + \mathrm{constant} \quad (1)$$

where $\alpha = -4$ (exponent of scaling law for absorption cross section) and **H** is the atmosphere scale height, we can infer

$$\mathrm{T} = 1294 \pm 425\ \mathrm{K} \quad (2)$$

in agreement with previous measurements.
- The technique can be applied to other expolanets and its importance can grow with the next generation of large telescopes and with instruments like ESPRESSO.

References

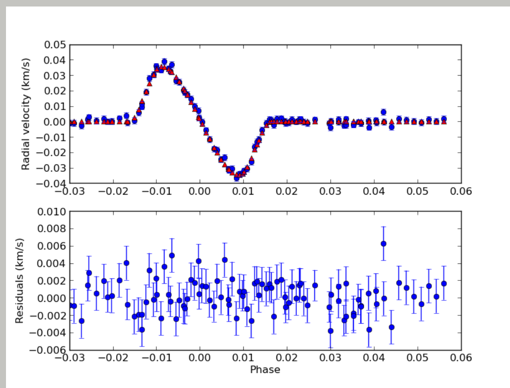
Claret, A. 2000, AA, 363, 1081
Pont, F., Knutson, H., Gilliland, R. L., Moutou, C., and Charbonneau, D. 2008, MNRAS, 385, 109
Sing, D. K., Pont, F., Aigrain, S., et al. 2011, MNRAS, 416, 1443
Snellen, I. A. G. 2004, MNRAS, 353, L1
Triaud, A. H. M. J., Queloz, D., Bouchy, F., et al. 2009, AA, 506, 377

Radial velocity data

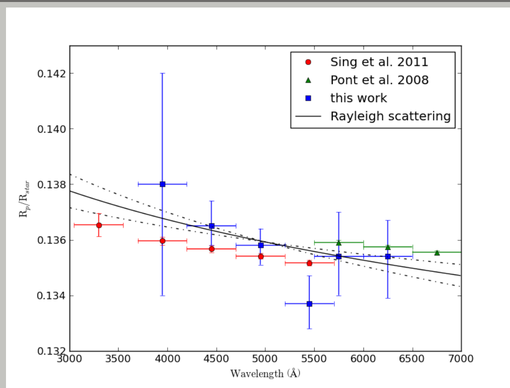
We used HARPS archival data corresponding to three observing nights (2006/09/07, 20 07/07/19, 2007/08/28). Total of 99 data points and 69 orders (HARPS spectrograph). We use the wavelength bins of Sing et al. 2011 and Pont et al. 2008.

RM model fitting

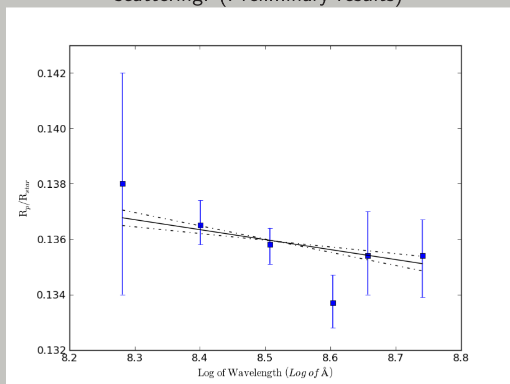
We fit the RV curves per each wavelength bin with a grid of models created fixing the orbital parameters and the limb darkening (dependent on wavelength), and varying the radius of the planet. Before fitting, we remove the residuals of the white RV curve fit from each of the orders, to account for systematic effects. One example (second bin) is reported in the figure below, with the residuals of that fit:



Results



Caption: $\mathrm{R_p/R_{star}}$ ratio in function of wavelength. Red: Sing et al. 2011 measurements, green: Pont et al. 2008 measurements (Hubble Space Telescope). Blue: our measurements using the RM effect with HARPS data. Black: dependence of the radii ratio on wavelength in case of Rayleigh scattering. (Preliminary results)



Caption: Rayleigh scattering law fit to the data. The fourth point has been excluded from the fit (law significance). The fit has a slope of -0.0036 ± 0.0012.

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