Ground-based narrow-band secondary eclipse observations of CoRoT-1b

UNIVERSITY OF EXETER Astrophysics

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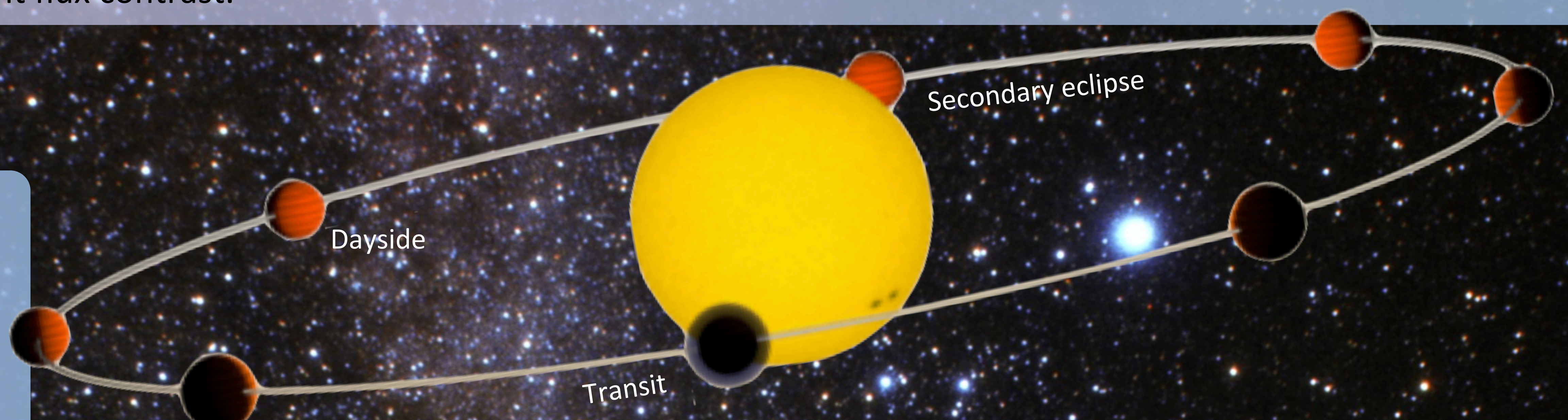
H. R. Wakeford & D. K. Sing*

Abstract

In an effort to constrain the emission spectra, albedo, and energy redistribution of the atmosphere of CoRoT-1b, we present H-band secondary eclipse observations. These were conducted using the Wide field Infrared camera (WIRCam) on Canada-France-Hawaii Telescope (CFHT) using a CH4 narrow-band filter. Our measured secondary eclipse depth is 0.157%±0.141% (a 1.1σ significance level), which occurs 4±3 minutes from the expected secondary eclipse. An unknown systematic error degrades our photometric accuracy, with changing weather conditions a possible source.
These observations form part of a project to measure the brightness temperature of hot Jupiters around an apparent 1800 K temperature transition regime where planets show a very strong day-night flux contrast.

Introduction

Detections of thermal emission from exoplanetary atmospheres have been widely achieved from the ground for a number of hot jupiters since 2009 (e.g. Sing, D.K. & Lopez-Morales, M. 2009; De Mooij et al. 2011; Zhao, et al., 2012). Including observations with WIRCam/CFHT, used to investigate some of the hottest hot Jupiters by Croll, B., et al. (2010a,b, 2011).



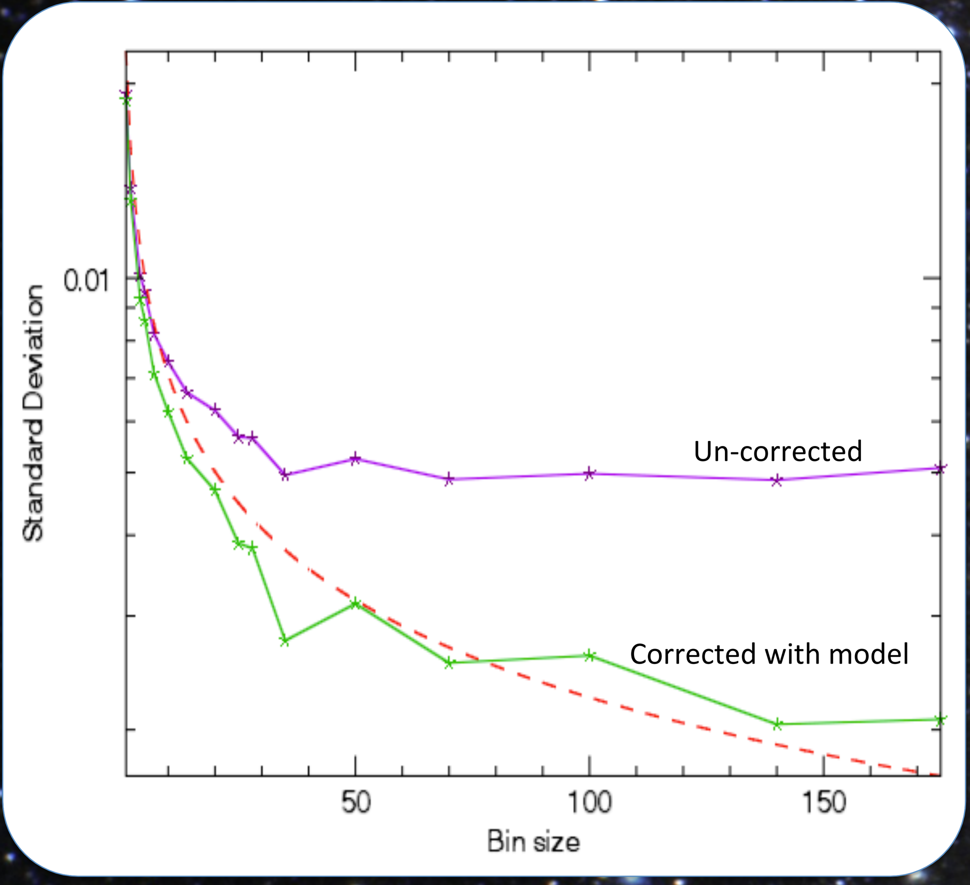


Figure 2: Comparison of CoRoT-1b's noise level with Gaussian noise expectation, for both the out-of-eclipse flux (purple) and the out-of-eclipse flux minus the model (green). The red dashed line is Gaussian noise expectation for each bin size.

Observations

CoRoT-1b was observed using the WIRCam instrument on CFHT during November 2009. H-band measurements were taken using the CH4 narrow-band photometric filter. The field of view encompassed the target star and 9 reference stars. A total of 1044 images in data cubes of 12 were taken, each with a 6 second exposure time, without dithering to reduce pixel position effects in the data.

Analysis

The images were pre-processed using the `I'iwi pipeline before aperture photometry was applied to the target and reference stars. An optimum aperture of 11 pixels and a sky annulus of 25-75 pixels.
To evaluate the systematic effects and the presence of red noise in the data we bin the normalised flux and compare the out of eclipse photometric precision to the Gaussian noise expectation of one over the square root of the bin size (Figure 2).
We fit for the secondary eclipse depth (ΔF), the background, and the centre of the eclipse (t_0). We also note a trend with airmass during the course of the observation, and this is incorporated into the model fitting.

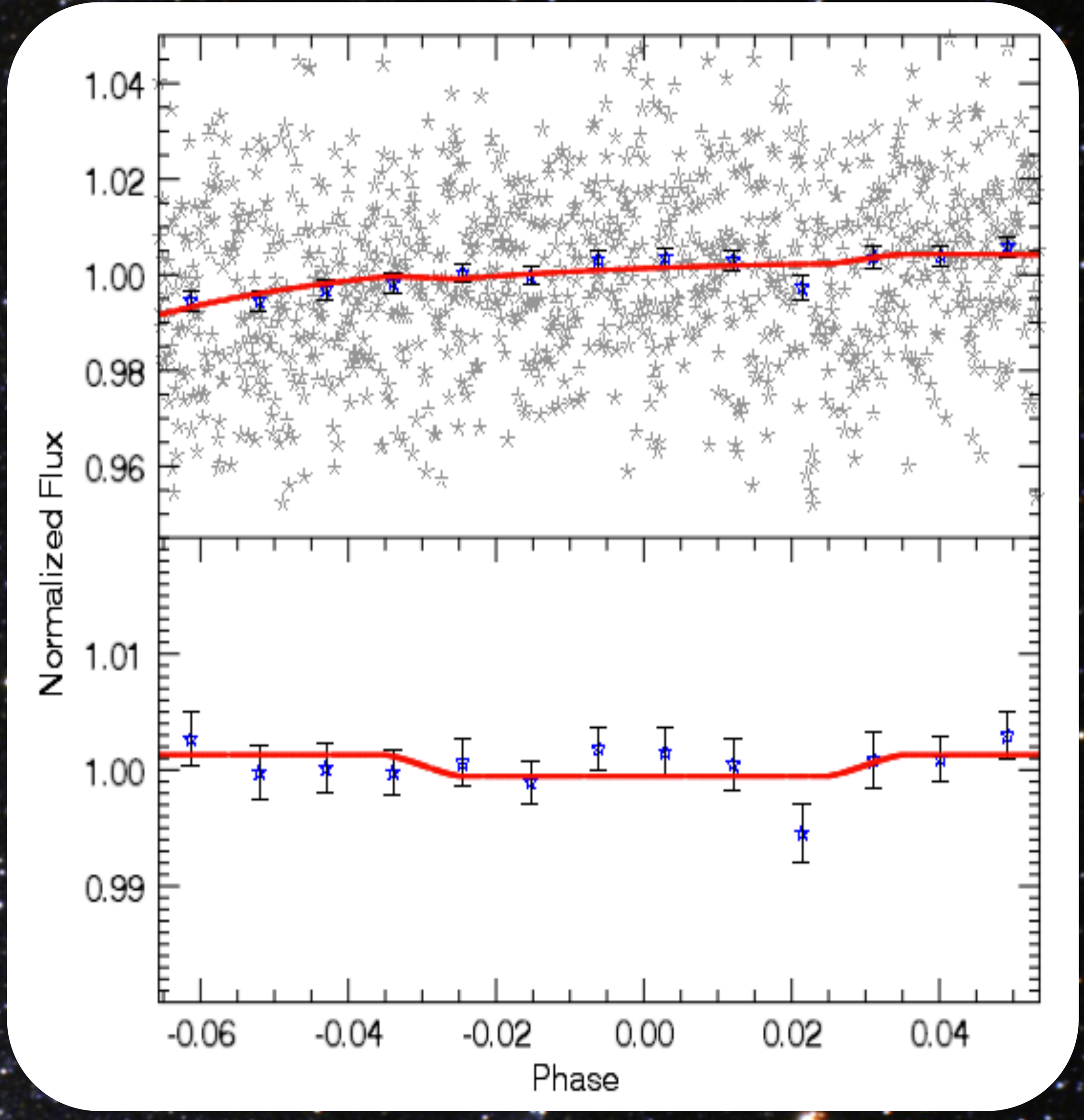


Figure 3: The left panel shows the unbind light curve with the best fit secondary eclipse. The right panel shows the light curve with the data binned every 20 minutes and again the best-fit eclipse.

Future Work

Over a series of future observations we aim to place constraints on the energy budget of hot Jupiters over a threshold temperature of 1800 K. In an effort to examine the apparent transition regime between hot Jupiters, and very hot Jupiters, as evidenced by a very strong day-to-night flux contrast.
Eight hot Jupiters have been selected as potential candidates that fit the observational criteria; Bright k-magnitude, expected secondary eclipse depth greater than 0.150%, planetary black body temperature above 1500K.

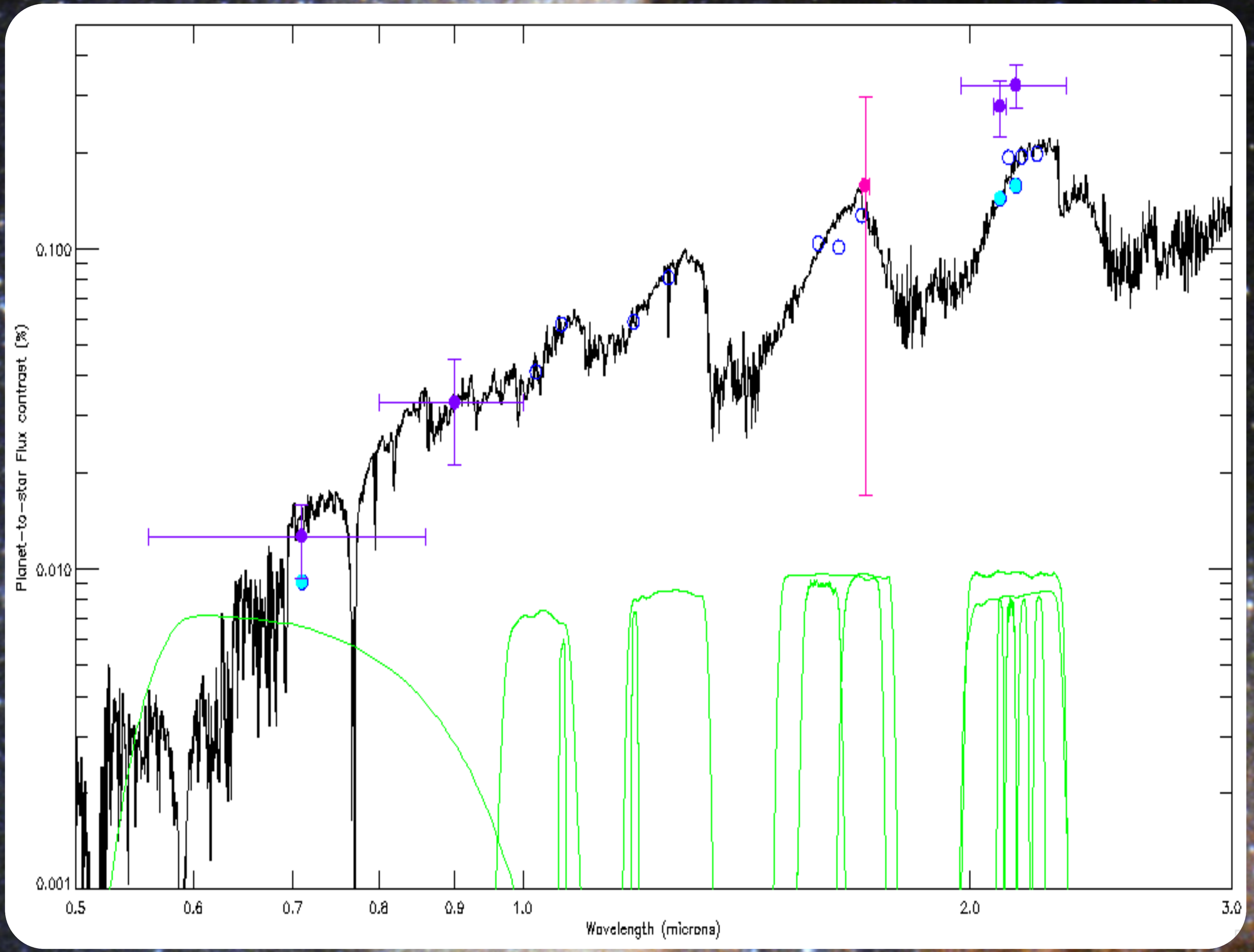


Figure 4: The measured planet-to-star flux ratios compared to the band averaged ratios from the Rogers et al. (2009) CoRoT-1b atmospheric model. Our result is marked in pink with a 1σ errorbar.

Conclusion

The observations show a weak secondary eclipse detection in the H-band (1.6 microns) with a measured secondary eclipse depth of 0.157%±0.141% (a 1.1σ significance level).
The low significance of the result is due to bad photometric weather conditions on the night and that CoRoT-1 is a relatively dim target star. It is possible that future secondary eclipse observations would be successful using the CH4 narrow band filter on WIRCam/CFHT with brighter target stars and better weather conditions; as no corrections were needed for the x and y pixel position so the method looks promising.
The model also fit to the expected centre of eclipse, which occurs at 4±3, further evidence of a detection. The result was added to previous atmospheric measurements of CoRoT-1b (see figure 4), which disfavors strong emission as suggested by previous measurements.

References

Croll, B., et al. 2010a, ApJ, 717, 1084
Croll, B., et al. 2010b, ApJ, 718, 920
Croll, B., et al. 2011, ApJ, 141, 30
De Mooij, et al., 2011, A&A, 528, A49
Rogers, J. C., et al., 2009, ApJ, 707, 1707
Sing, D.K., & Lopez-Morales, 2009, A&A, 493, L31
Zhao, et al., 2012, ApJ, 744, 122

*hannah@astro.ex.ac.uk