Observations of CoRoT-2b with the Liverpool Telescope

(and some preliminary results)

Hannu Parviainen
Instituto de Astrofísica de Canarias

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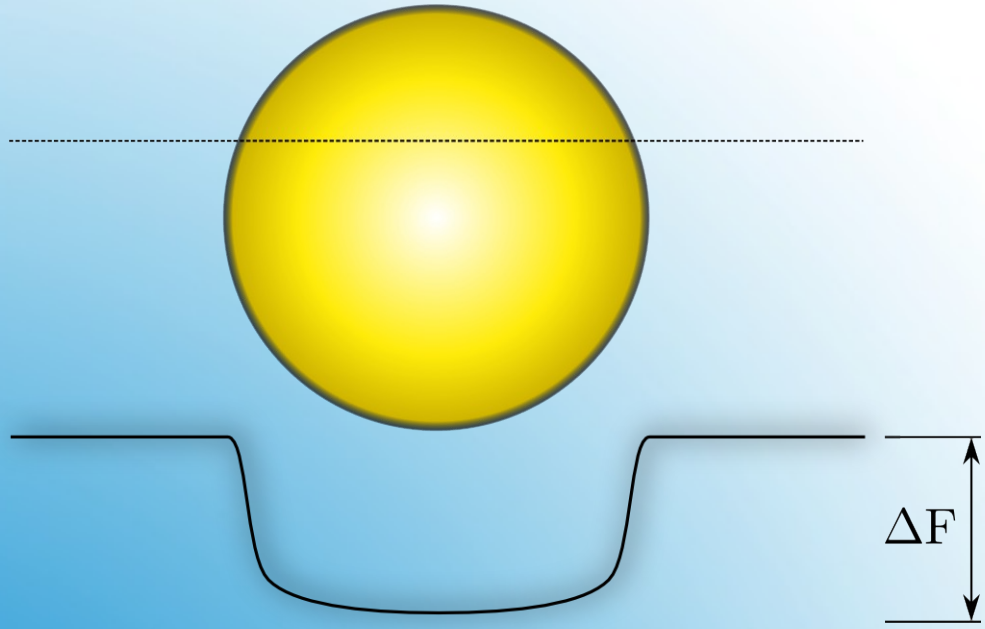
The effects of stellar variability on transit depth

Theory - K from transit depth

- Planet to star radius ratio (k) can be inferred from the transit depth

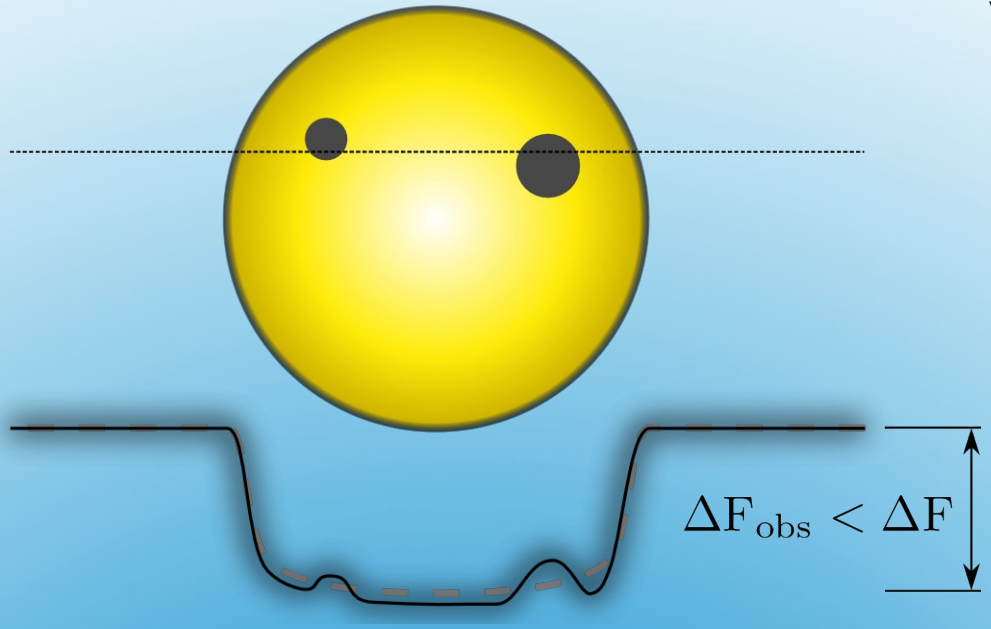
$$k = \sqrt{\Delta F / F}$$

- Applies only if the stellar disk is homogeneous!
  - Excluding limb darkening



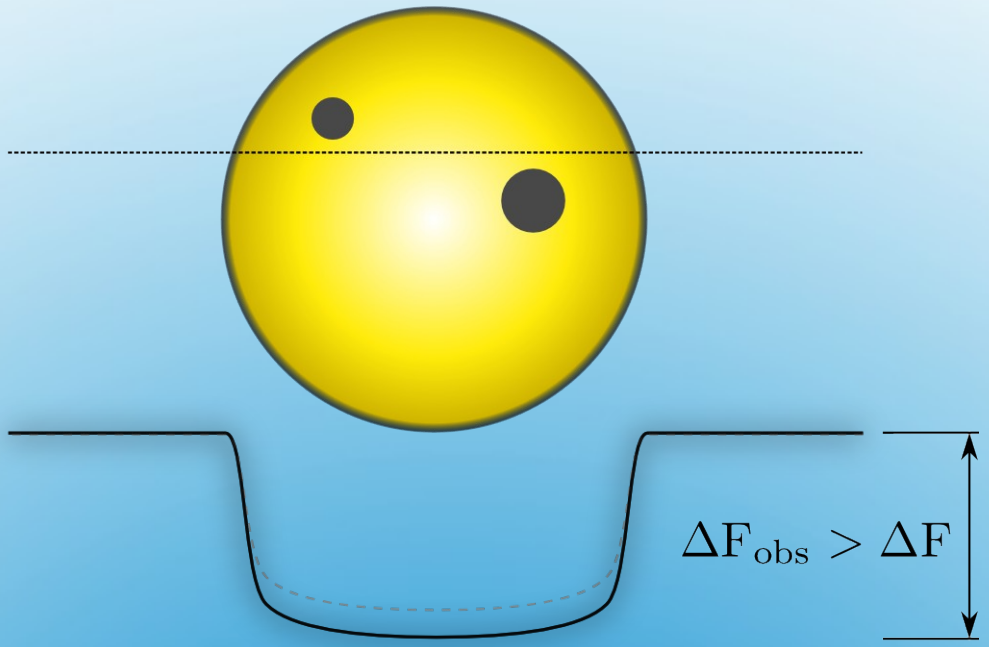
- Inhomogeneus brightness distribution
  - Spots
  - Spiculas
- Spots can lead to misestimation of the planetary radius
  - Both over- and underestimation, depending on whether the planet crosses over the spots or misses them

Theory - Stellar activity causes problems



- Averaging over transit yields shallow ΔF
  - Decreases the radius by $\Delta F^{1/2}$
  - Increases the density by $\Delta F^{3/2}$

Theory - radius underestimation



- There are spots but the planet misses them
  - Deeper transit
  - Increases radius
  - Decreases density

Theory - radius overestimation

- Spot contrast is sensitive to the observed passband
- Spots can be distinguished from noise by simultaneous multicolour observations
  - The spots can be filtered out for a more accurate measurement of radius
  - The spot distribution can be inferred from repeated transit observations

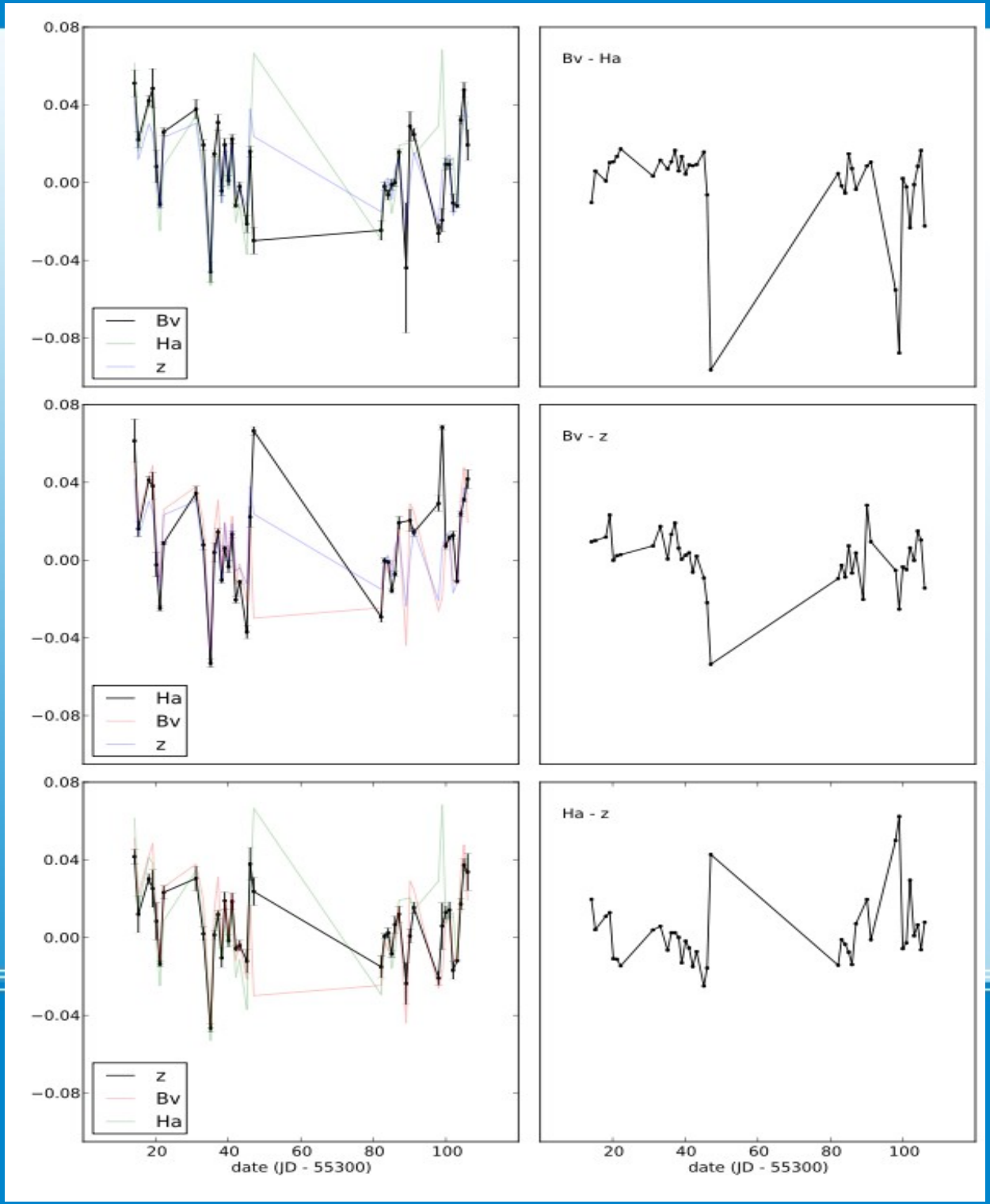
Theory - Good news

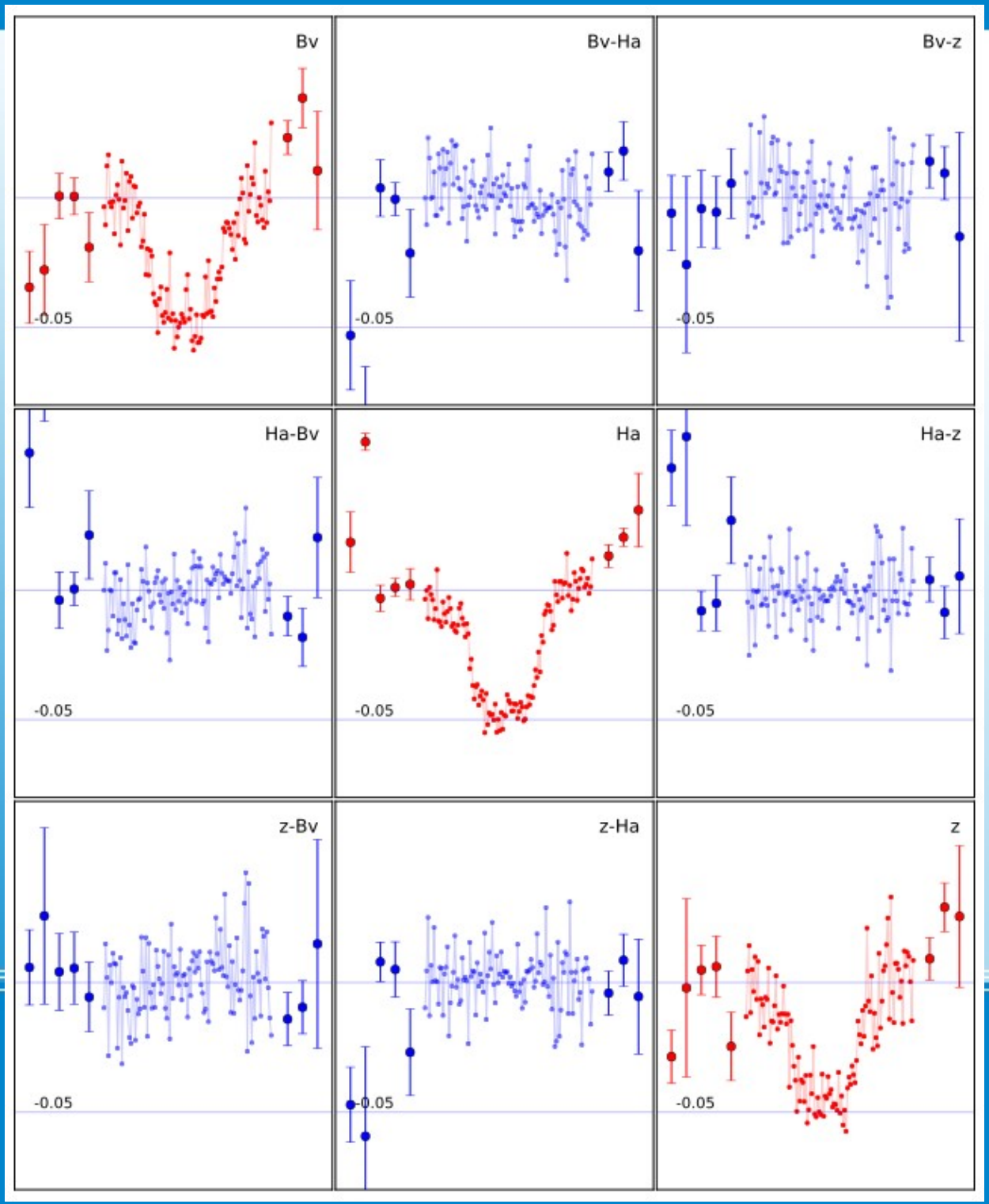
Observations

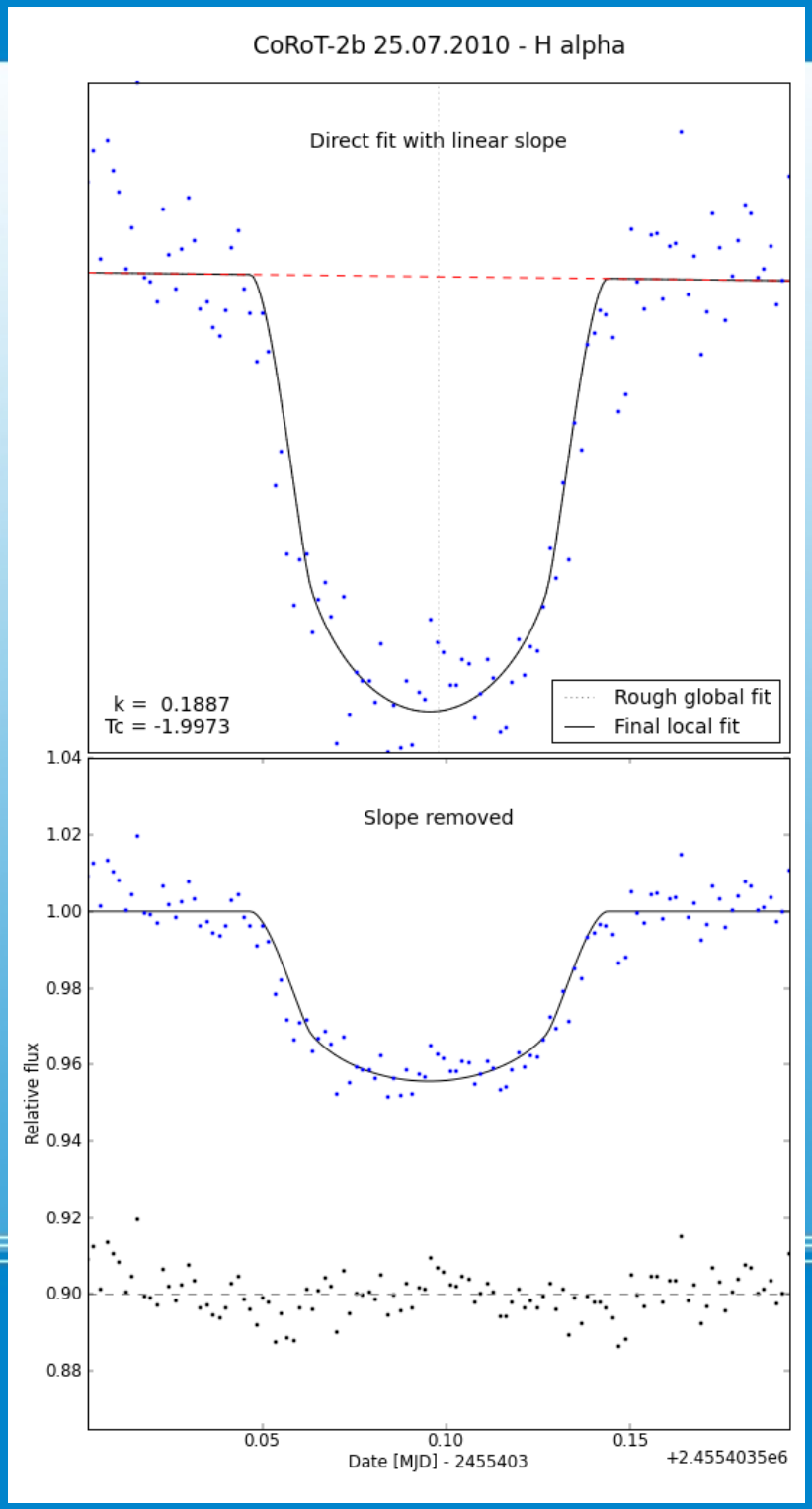
- Aim was to
  - Observe three full transits of CoRoT-2b in 2010A
  - Combined with a week of short calibration observations after and before the transit to characterize the variability
- Using three filters
  - Bessel V
  - H alpha
  - Sloan z

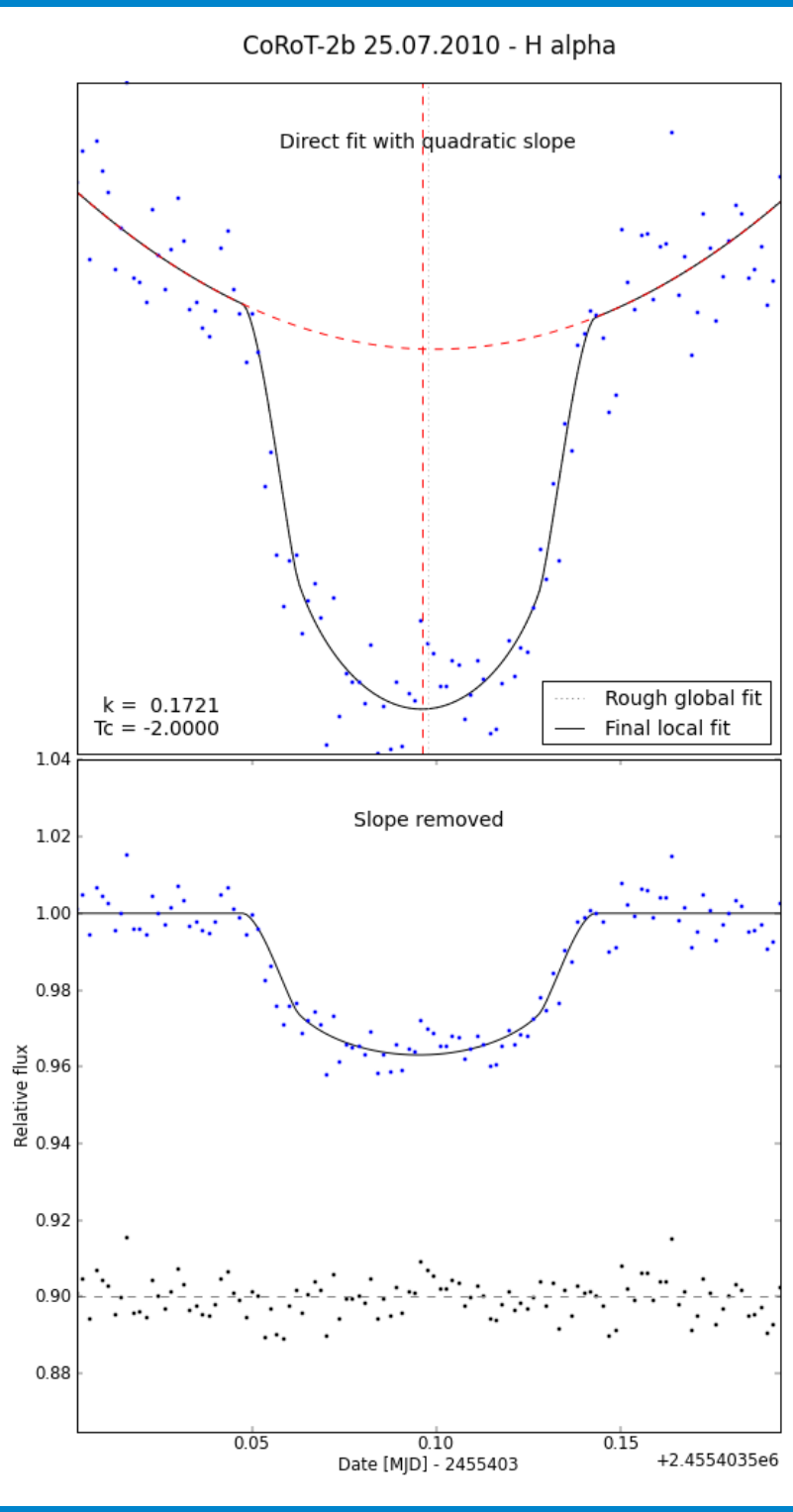
- Bad luck
  - The program was stressful to the LT
  - Software bugs and technical failures
  - (and occasional bad weather)
- The LT crew donated us some extra time
  - One full transit
  - 37 nights of calibration observations

Observations - results


0.08
0.04
0.00
−0.04
−0.08
Bv
Ha
z
Bv - Ha
Ha
Bv
z
Bv - z
z
Bv
Ha
Ha - z
20
40
60
80
100
date (JD - 55300)
date (JD - 55300)


Bv
-0.05
Bv-Ha
-0.05
Bv-z
-0.05
Ha-Bv
-0.05
Ha
-0.05
Ha-z
-0.05
z-Bv
-0.05
z-Ha
-0.05
z
-0.05


CoRoT-2b 25.07.2010 - H alpha
Direct fit with linear slope
k = 0.1887
Tc = -1.9973
Rough global fit
Final local fit
Slope removed
Relative flux
Date [MJD] - 2455403
+2.4554035e6


CoRoT-2b 25.07.2010 - H alpha
Direct fit with quadratic slope
k = 0.1721
Tc = -2.0000
Rough global fit
Final local fit
Slope removed
Relative flux
Date [MJD] - 2455403
+2.4554035e6

- Assuming linear slope
  - Transit deeper than what previously observed
    - k=0.19, latest published k=0.17
  - Difference may be too big to be explained by the transit simply missing the spots
- Assuming quadratic slope
  - Transit depth in agreement with previously published values
  - But it would be a strange coincidence that the minimum matches with the transit center

Results

- We need to increase the time before ingress and after egress in order to characterize the stellar level well enough.
  - Planet radii and densities inferred from the transit depths are sensitive to the model used to characterize the stellar level.
- Several transits may be necessary in order to obtain reliable radius estimates for transits over active stars.

Lessons learned

- We submitted a proposal asking for a rerun of the program in 2011A
- We will adapt the observations based on our experience from this run

Future

Thank you!