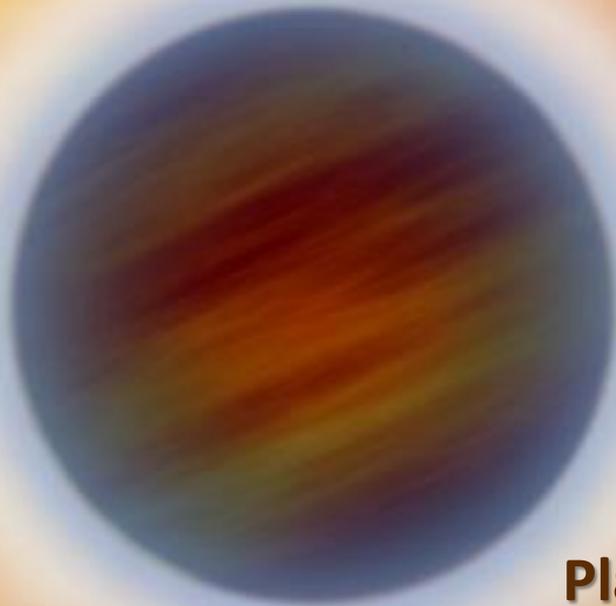


Ground-based Spectroscopy of Exoplanet Atmospheres



Lisa Nortmann

Stefan Dreizler

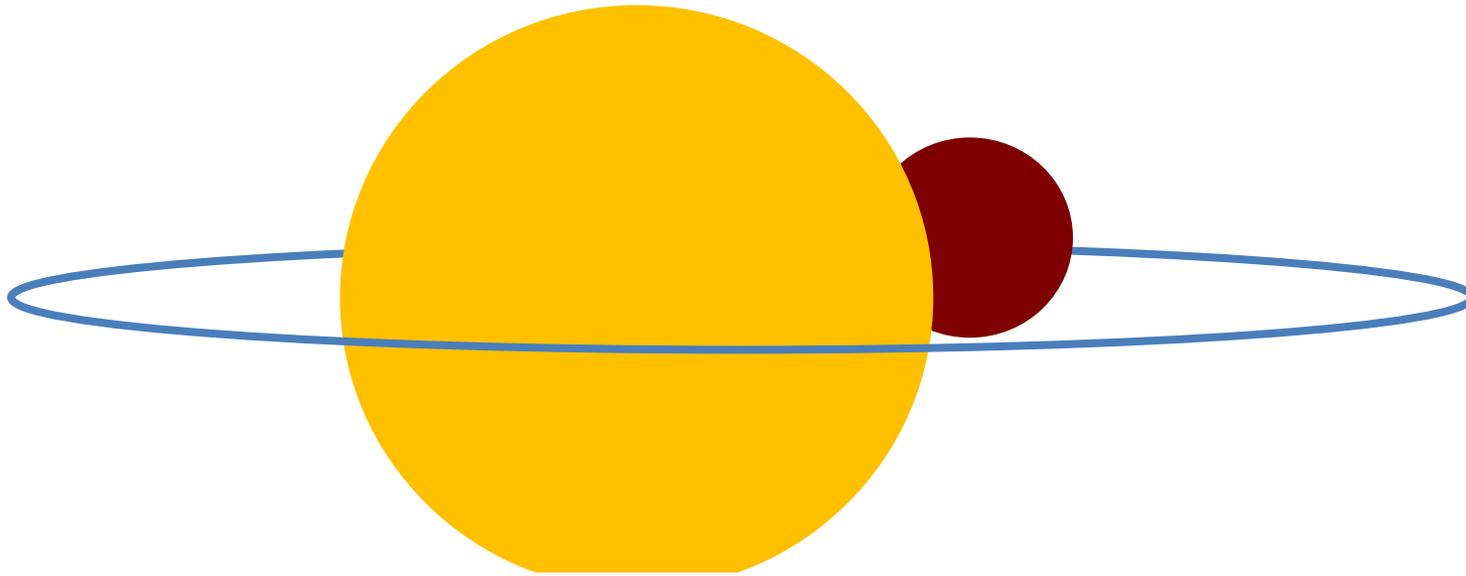
University Göttingen

DFG RTG 1351

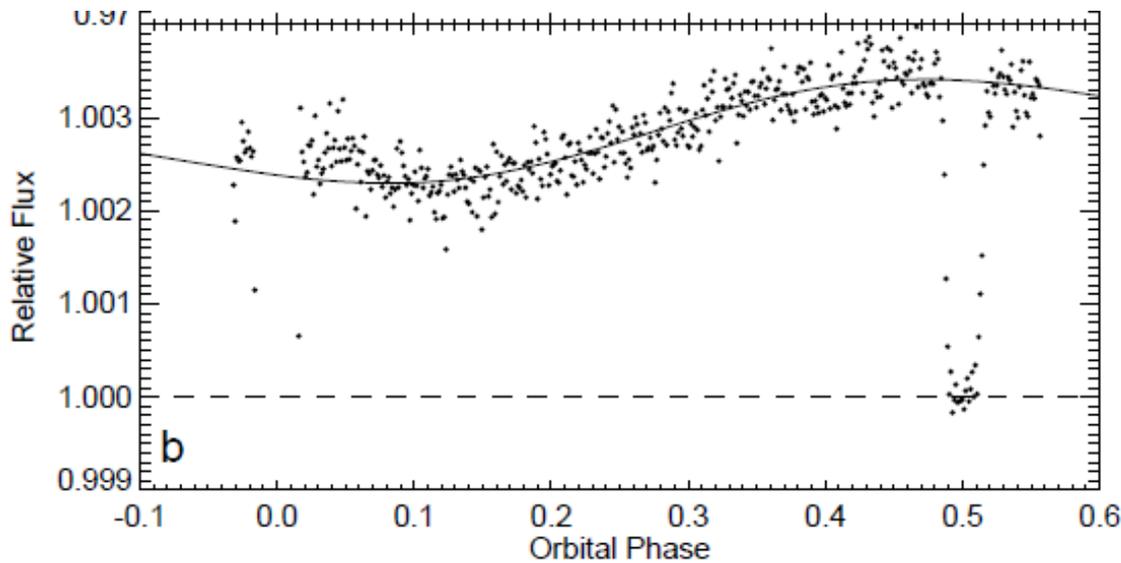
Planet Formation and Evolution

September 3.-7. 2012, Munich

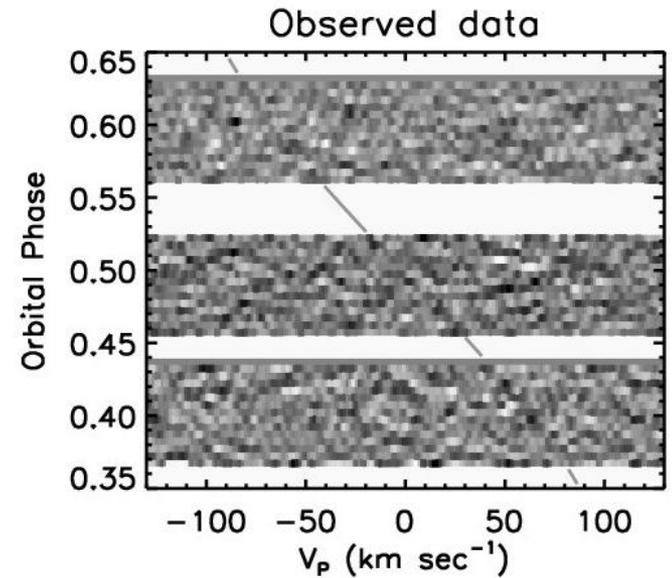
Secondary Eclipse and Phase Resolved RVs



HD 189733b, Knutson et al. 2007

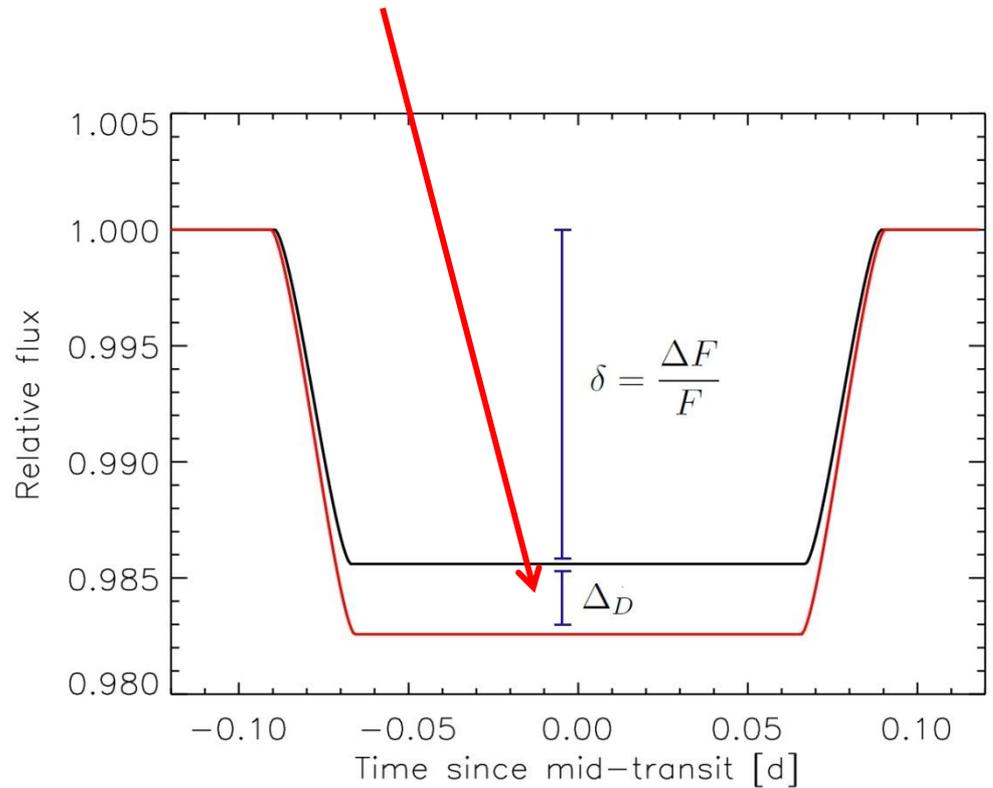
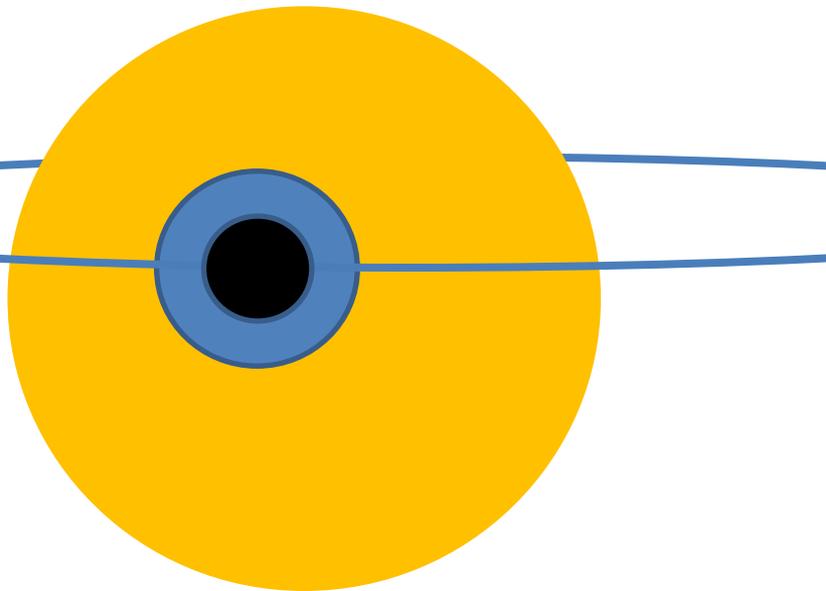


Tau Boo b, Brogi et al. 2012



Transmission spectroscopy

Required precision: 10^{-4}



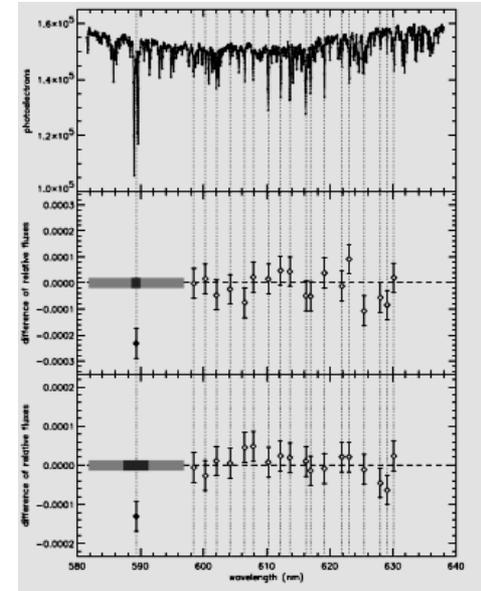
Previous Observations

Space-based

→ HST/STIS: first successful detection

e.g. NaD in HD 209458b

Charbonneau et al. 2002



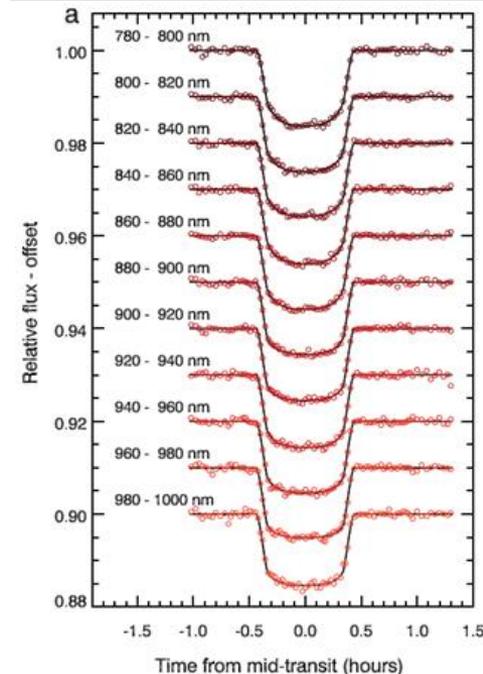
Ground-based

Issue: correct for telluric atmospheric effects

→ 10m class telescopes, many tries, partly successful,

e.g. FORS2/VLT multi-object Spectrophotometry

GJ 1214b, Bean et al. 2010



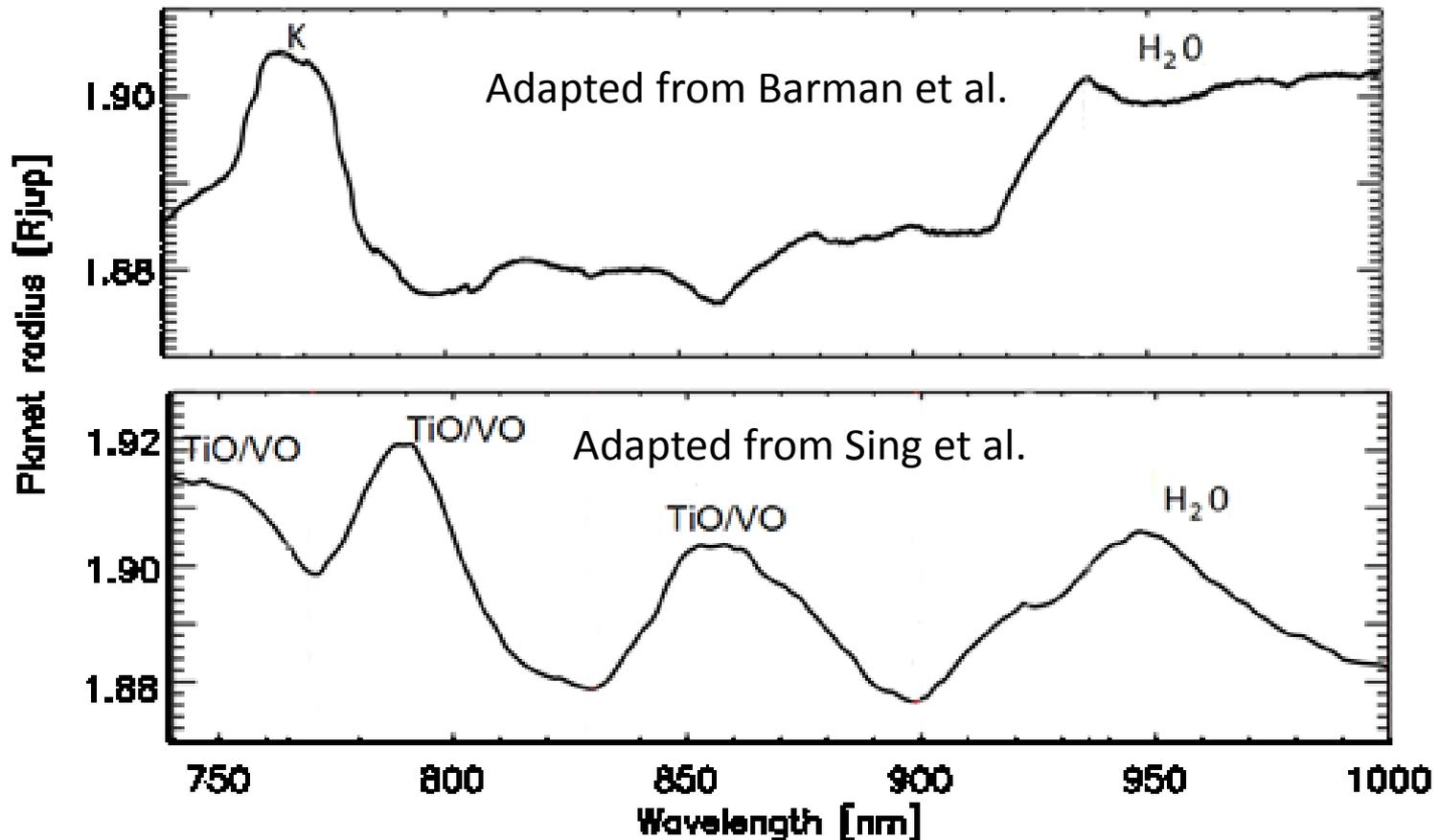
Our Observations

Target: WASP-17b

→ The planet with the lowest density ($\sim 0.1 \text{ g/cm}^3$)

Wavelength range: 740-1000 nm

→ K, H₂O and TiO absorption predicted by models

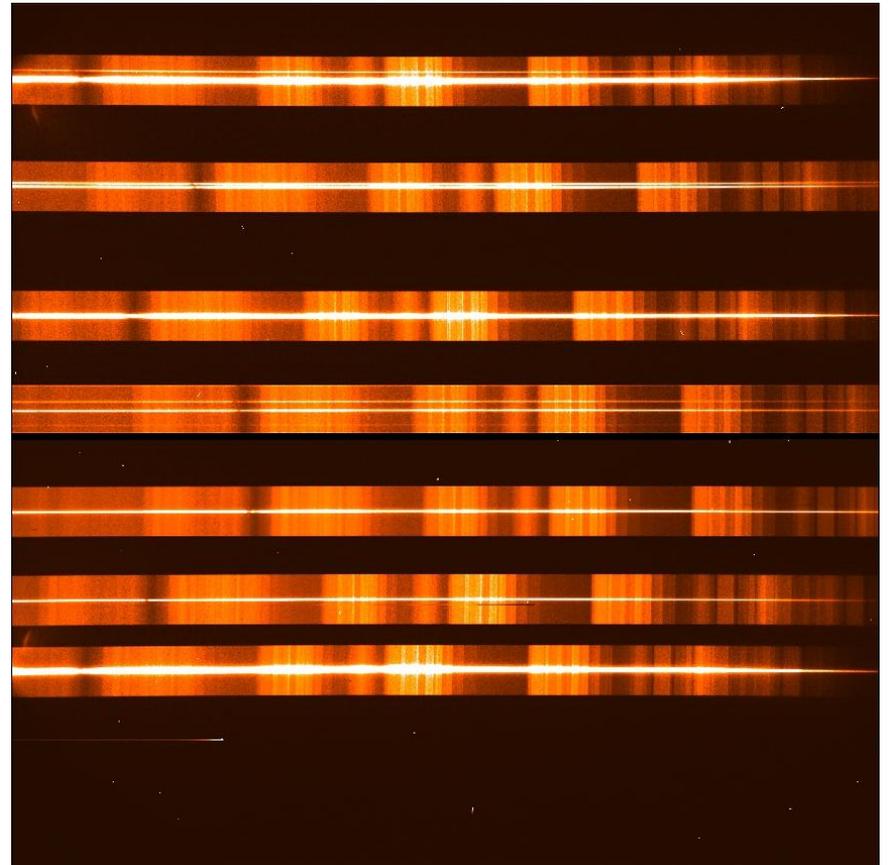
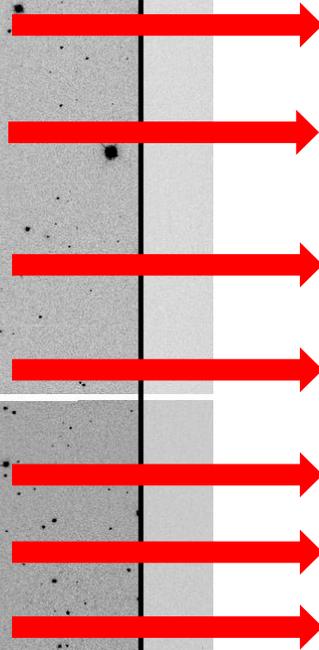
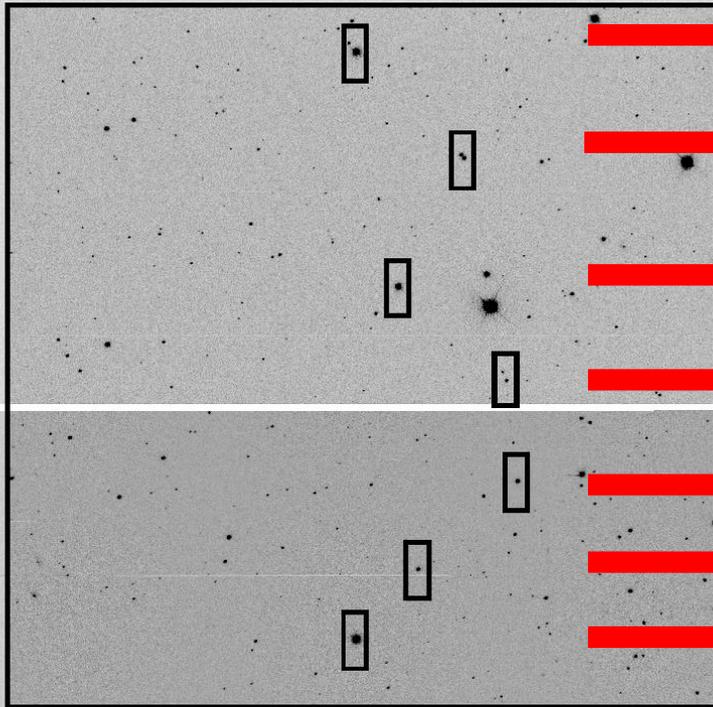


Our Observations

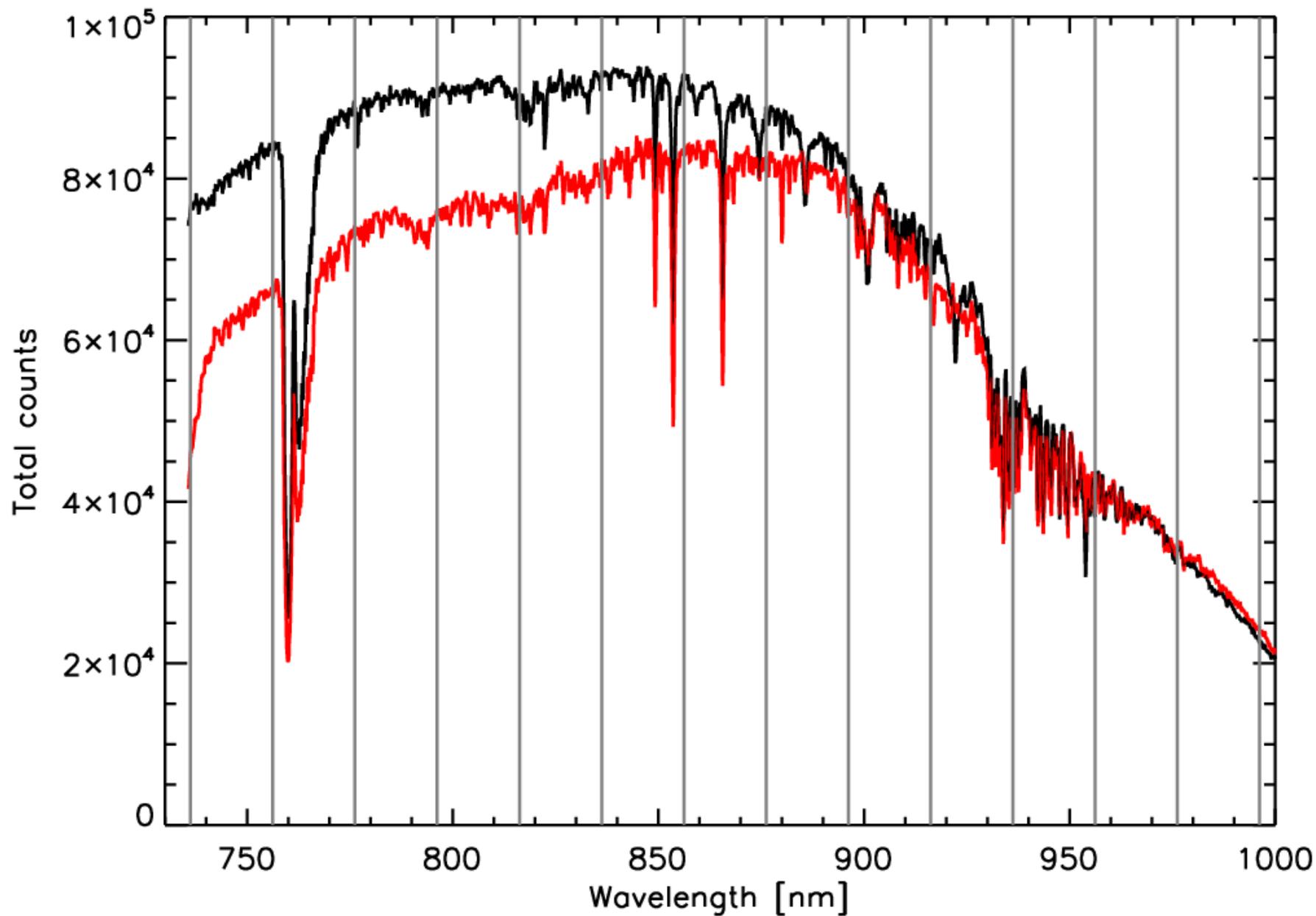
Instrument: FORS2 mounted at ESO VLT

used in MXU (Multi-Object Spectroscopy with mask)

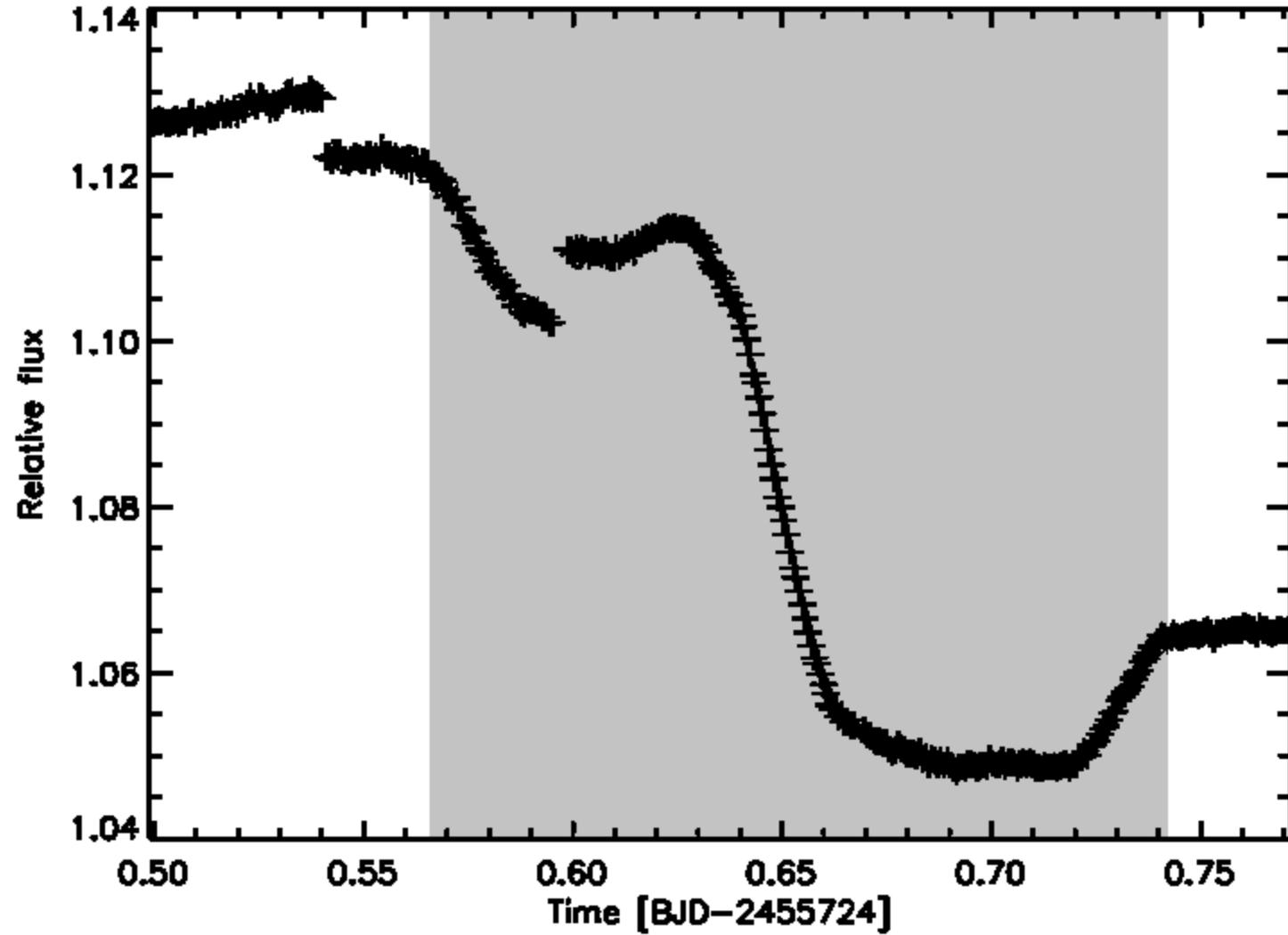
Simultaneously observing WASP-17 + 6 reference stars



Spectrophotometry

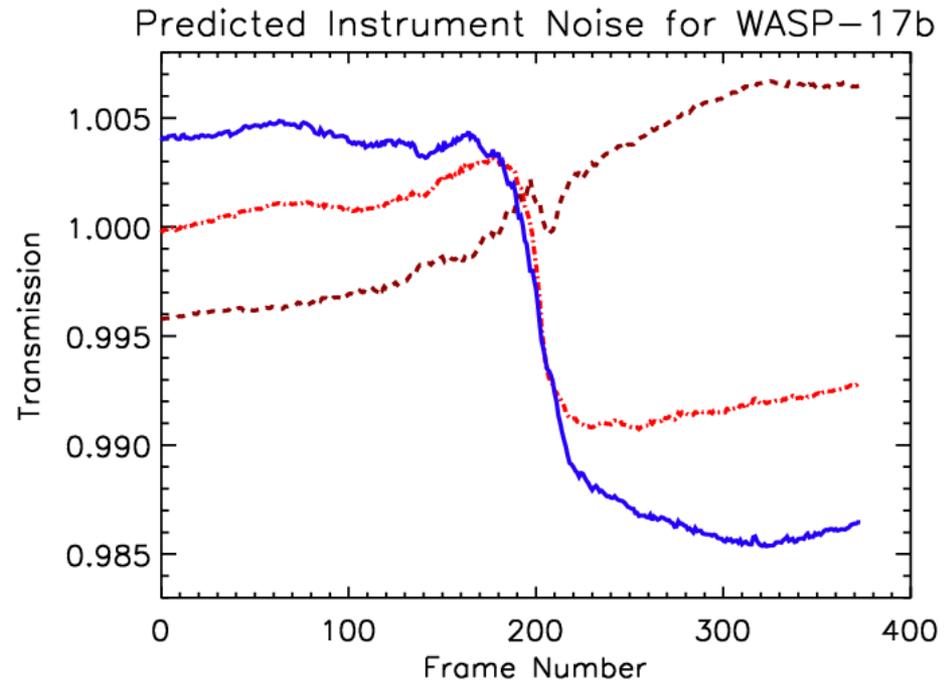
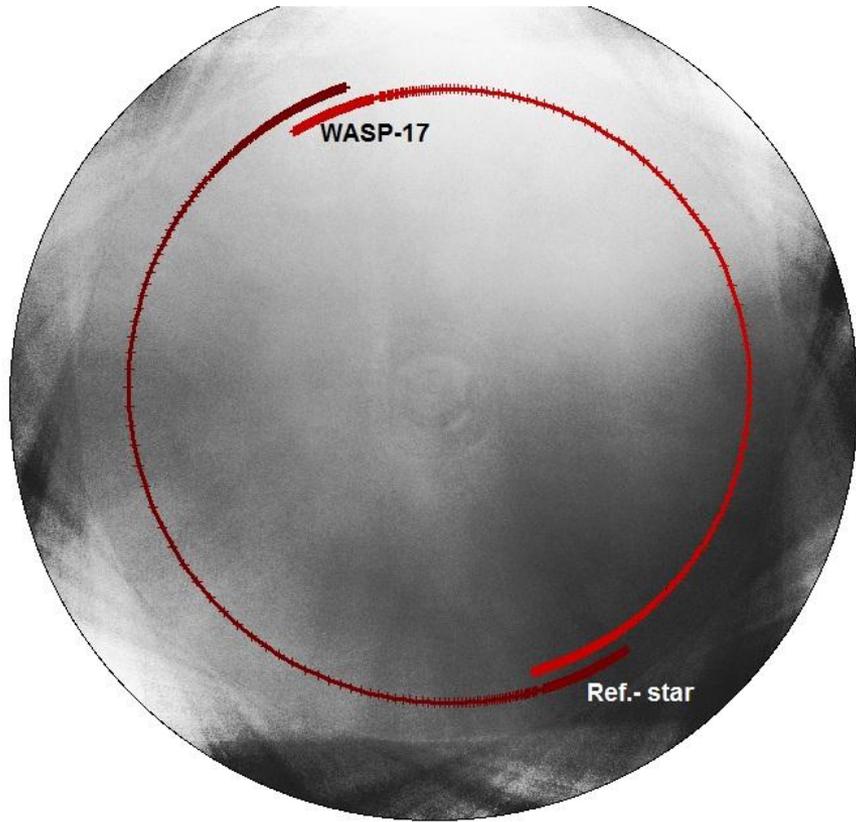


Transit Light Curve of WASP-17b

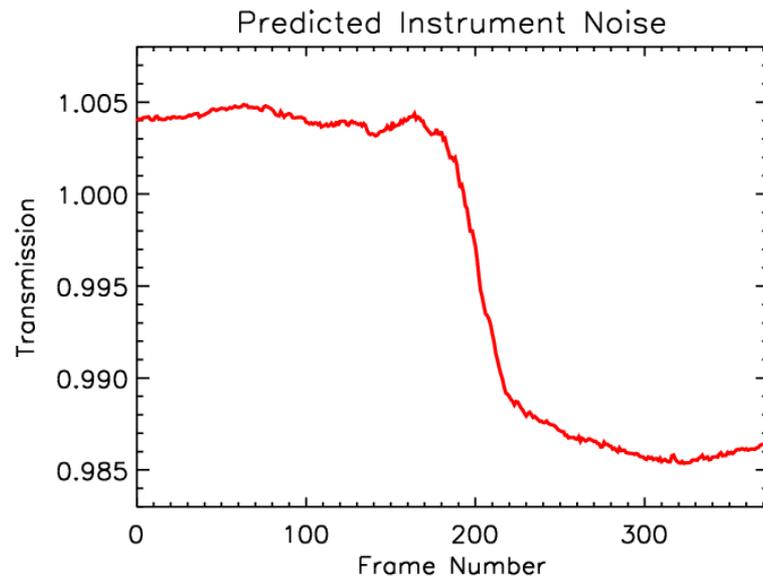
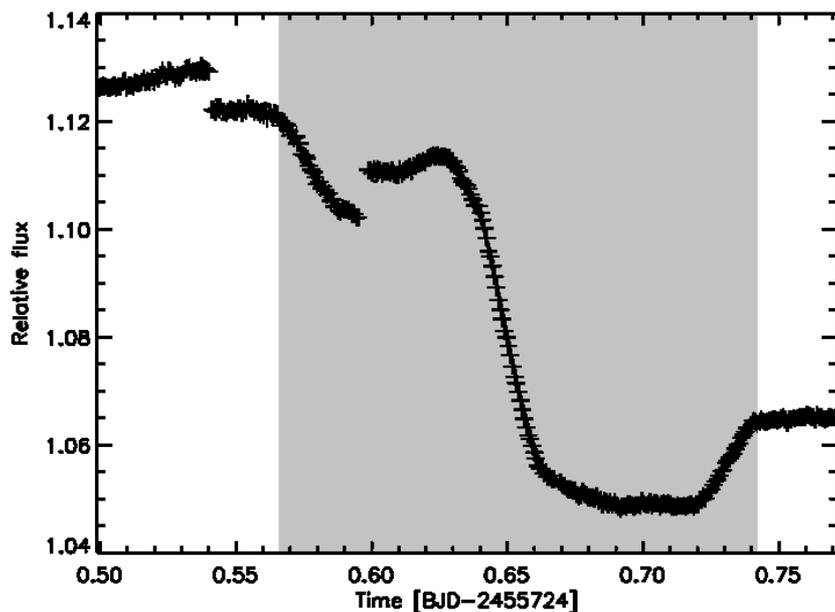


Main Source of Systematic Noise

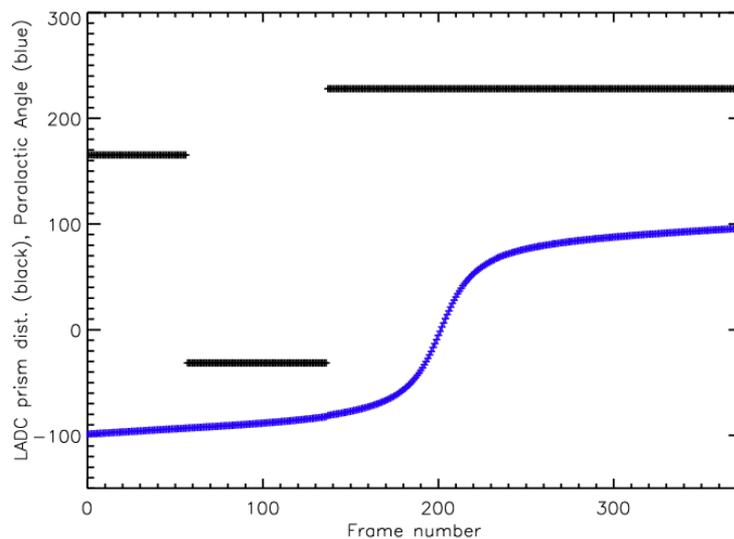
- Rotation Dependent Instrument Inhomogeneity -



Light Curve Detrending



$$M(\lambda) = T(r_p(\lambda))(a_1(\lambda) \cdot \Delta_{LADC})(a_2(\lambda) \cdot \theta_{PA} + a_3(\lambda) \cdot \theta_{PA}^2 + a_4(\lambda) \cdot \theta_{PA}^3)$$



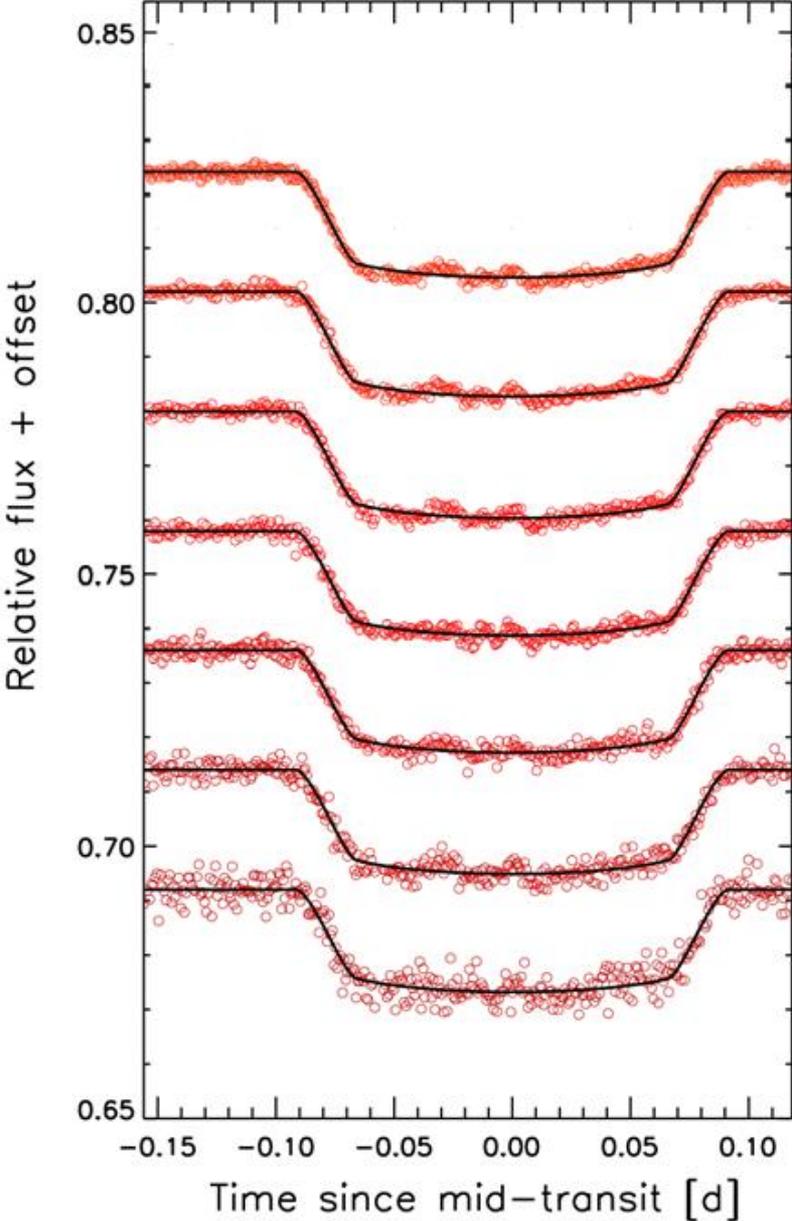
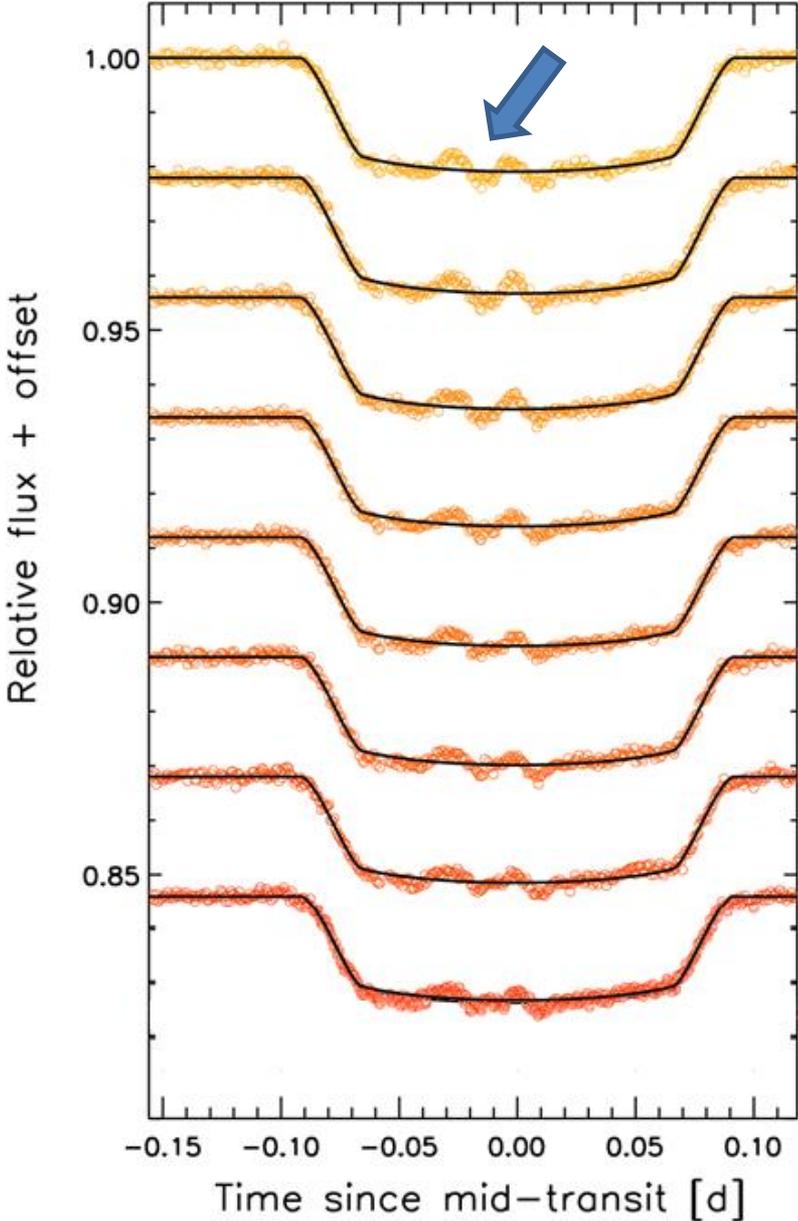
LADC prism distance

— Δ_{LADC}

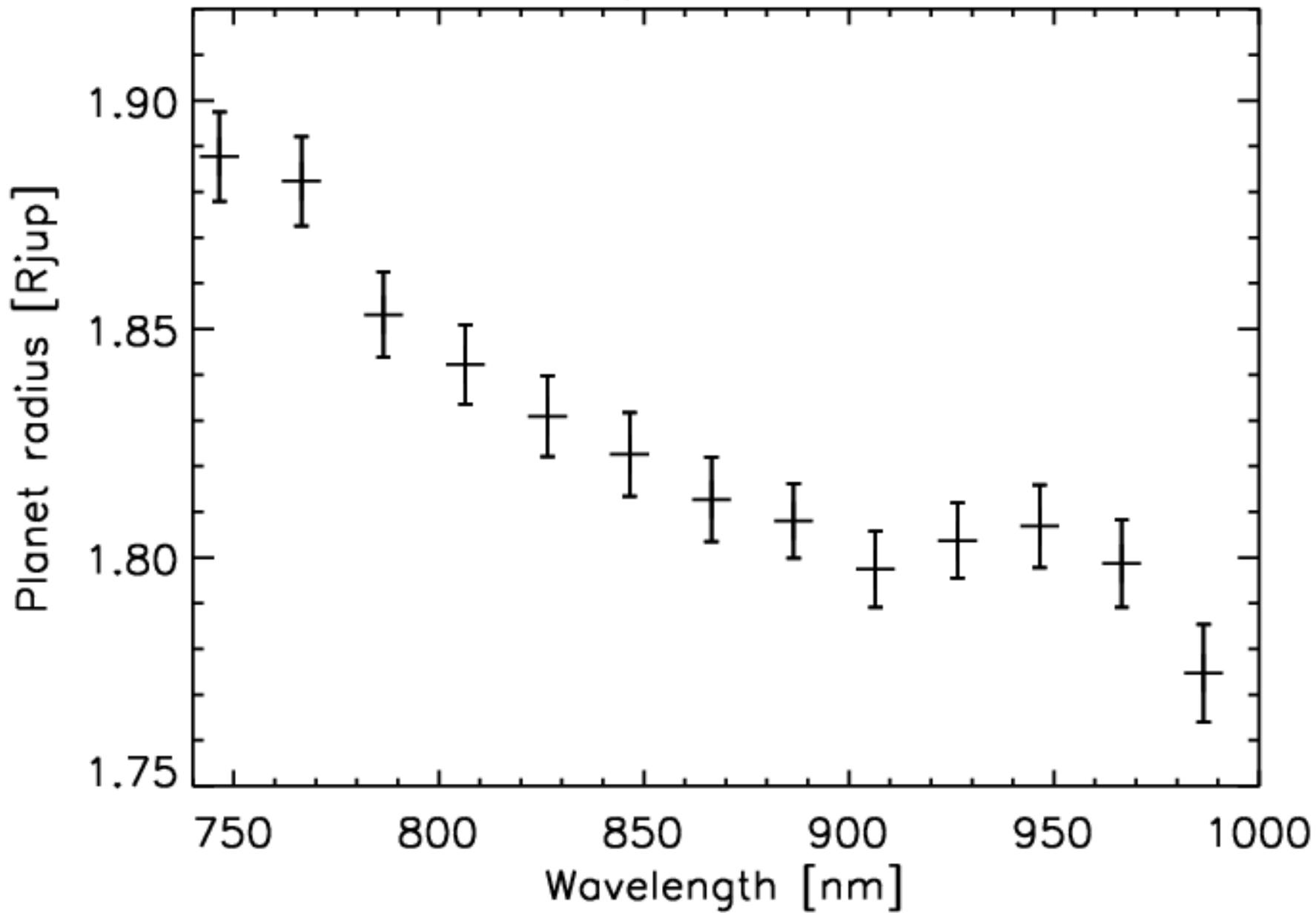
Parallax angle

— θ_{PA}

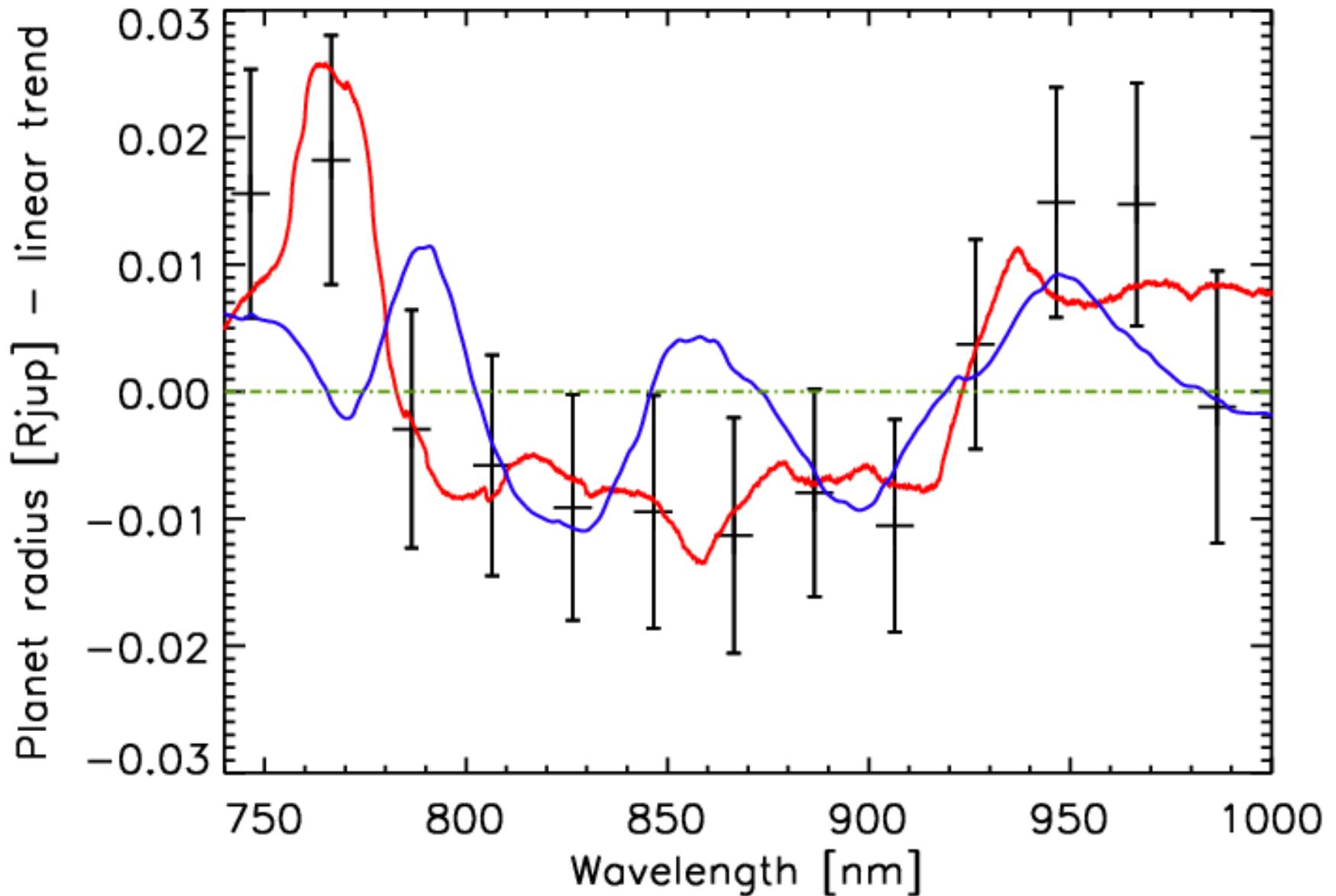
Wavelength dependent transit light curves



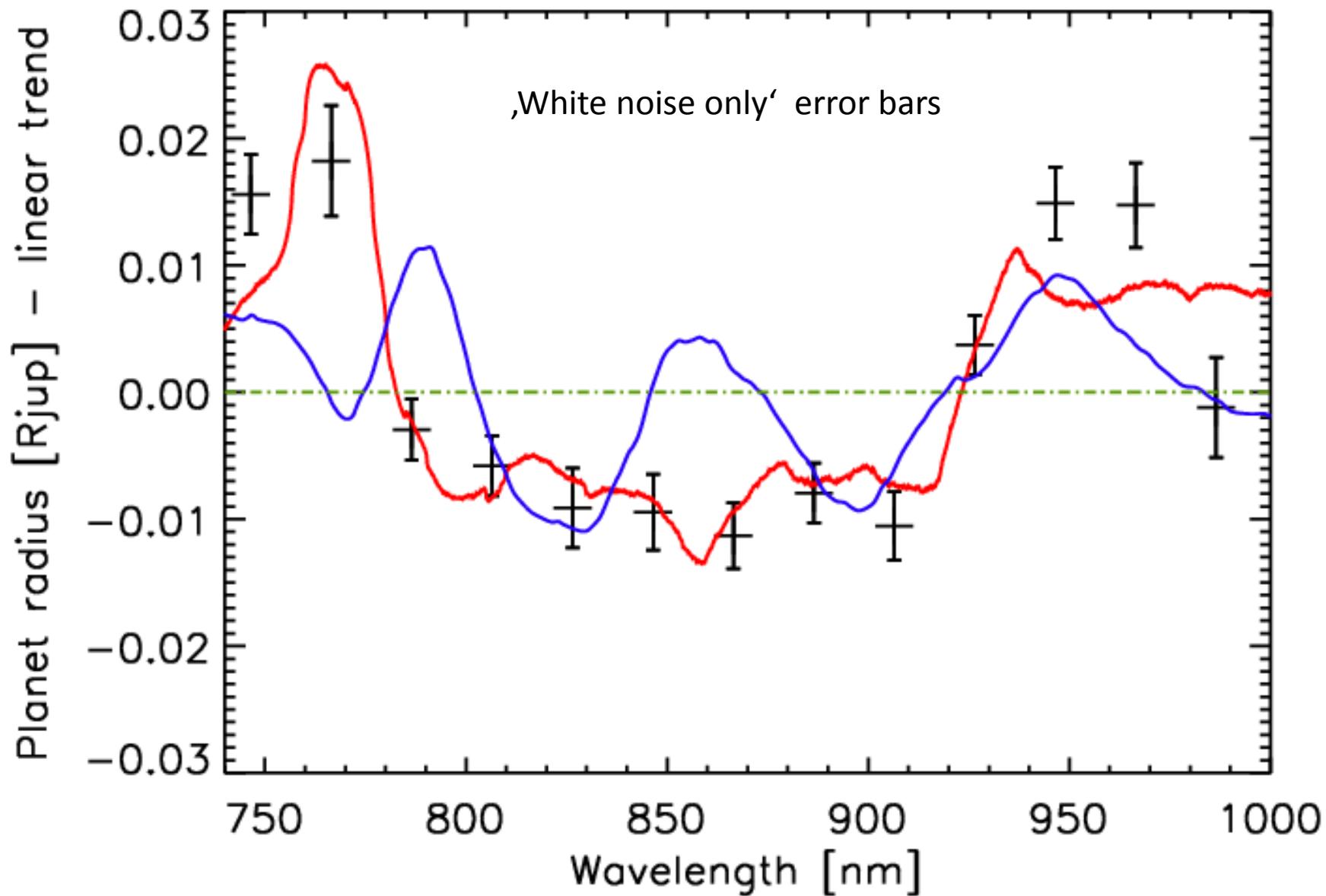
Transmission spectrum of WASP 17b



Transmission spectrum of WASP 17b



Transmission spectrum of WASP 17b



Conclusions

The **potential** of ground-based transmission spectroscopy **is high**.
However most observations are affected by systematic noise
The current instruments have not been designed for this purpose

- No calibration for **systematic noise** up to the desired precision
- We aim to develop such calibration.
- This requires combination of several existing data sets
- Might require additional calibration data to be taken.

We need to understand the nature and sources of these trends
so they can be avoided in the design stage of future dedicated instruments or
the necessary calibration information can be obtained in time.