LRG-BEASTS: sodium absorption and Rayleigh slope in the atmosphere of WASP-94A b using NTT/EFOSC2

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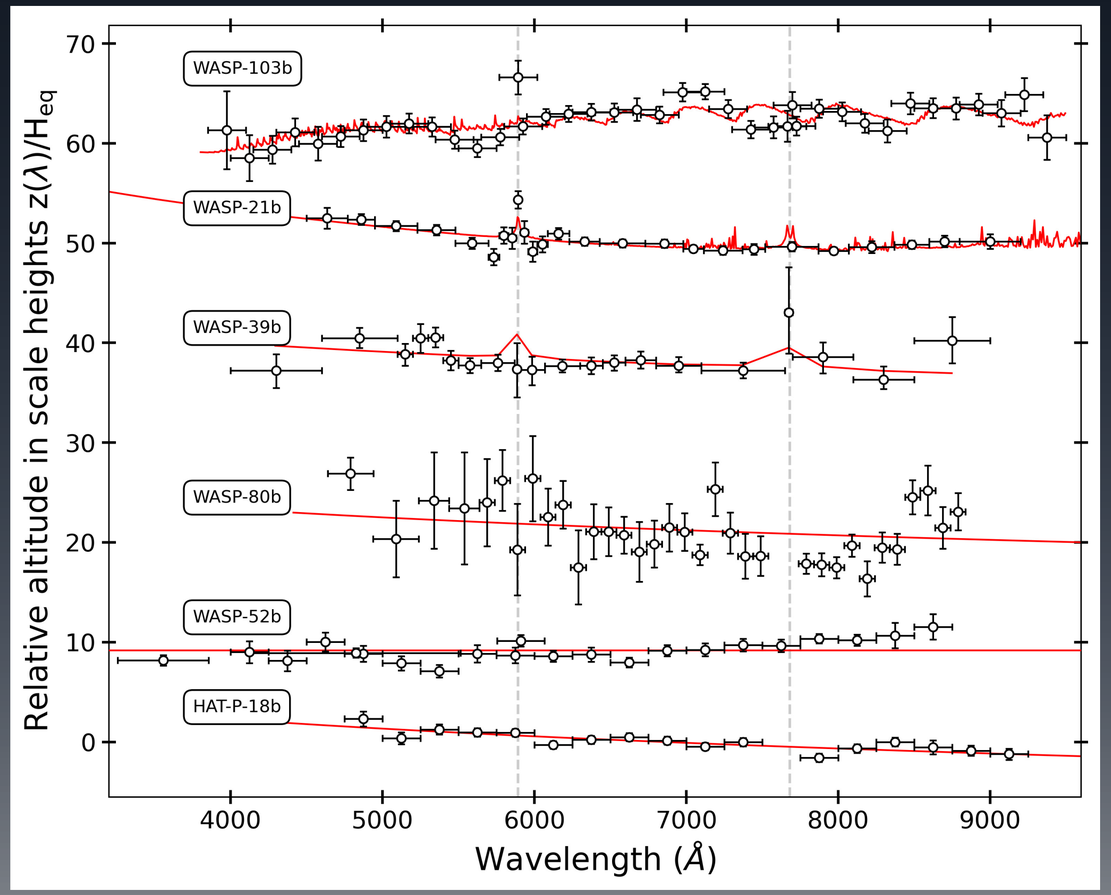
ESO ATMO 2021: Atmospheres, Atmospheres!
Do I look like I care about atmospheres?

Supervisor: Peter Wheatley
Collaborators: James Kirk, Sid Gandhi, George King, Tom Louden

LRG-BEASTS Low Resolution Ground-Based Exoplanet Atmospheres Survey using Transmission Spectroscopy

- To provide a large sample of optical transmission spectra of hot Jupiter atmospheres
- 4-metre class telescopes: WHT/ACAM, NTT/EFOSC2
- To constrain the effects of clouds and hazes on the transmission spectrum



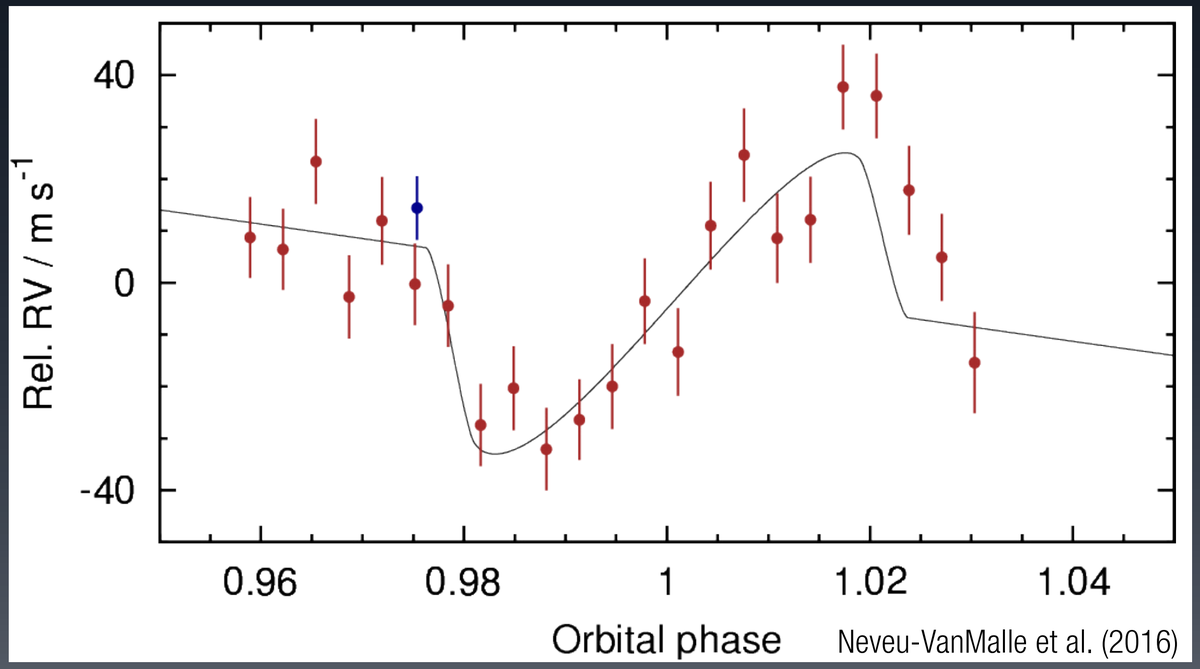
Published results to date (bottom to top):
Kirk et al. (2017), Louden et al. (2018), Kirk et al. (2018), Kirk et al. (2019), Alderson et al. (2020), Kirk et al. (2021)

The WASP-94 system

Neveu-VanMalle et al. (2016), Garhart et al. (2020)

	WASP-94A	WASP-94B
Sp	F8	F9
V_{mag}	10.1	10.5

WASP-94A b	WASP-94B b	
3.95 d	2.00 d	Period
0.456 M_{Jup}	0.62 M_{Jup}	Mass
1.72 R_{Jup}		Radius
~1500 K		Equilibrium Temperature

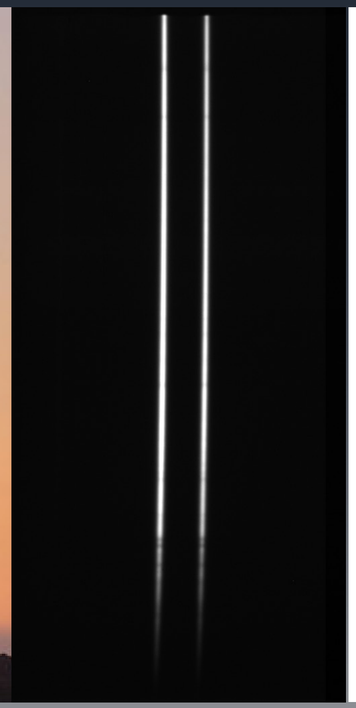


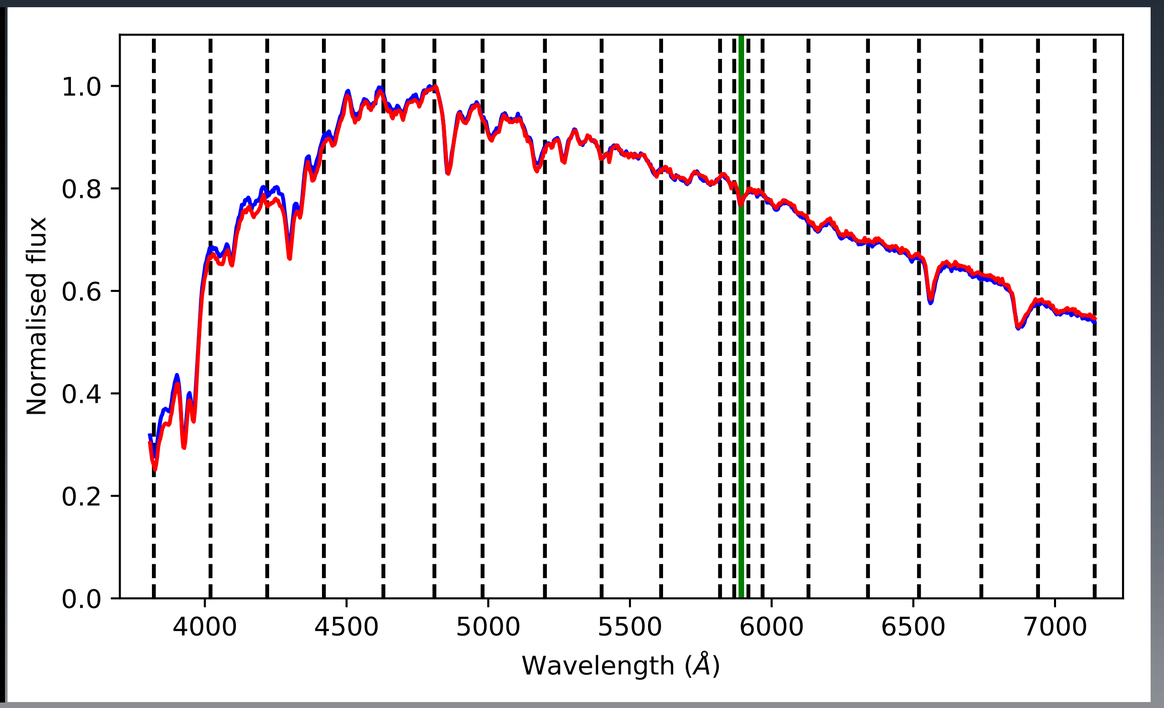
Rossiter-McLaughlin Effect:
WASP-94A b is misaligned and likely in a retrograde orbit ($\lambda = 151° \pm 20°$)

Observations

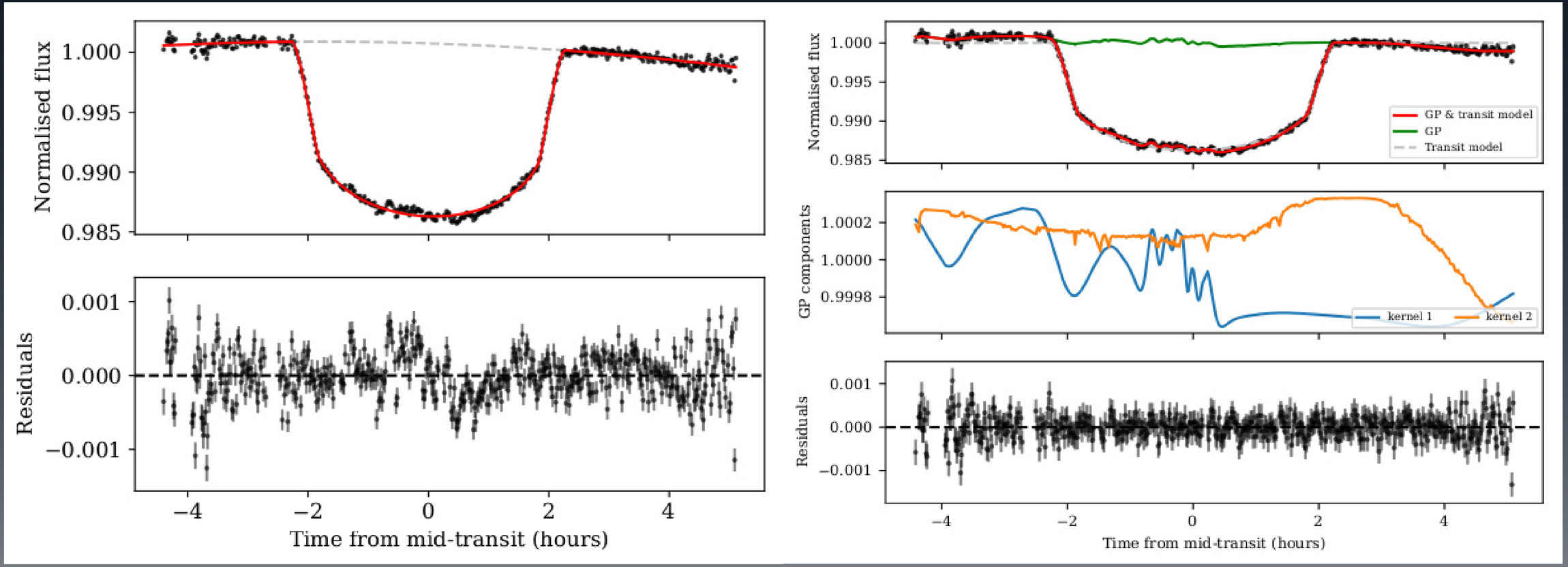
EFOSC2 at the New Technology Telescope (NTT), La Silla

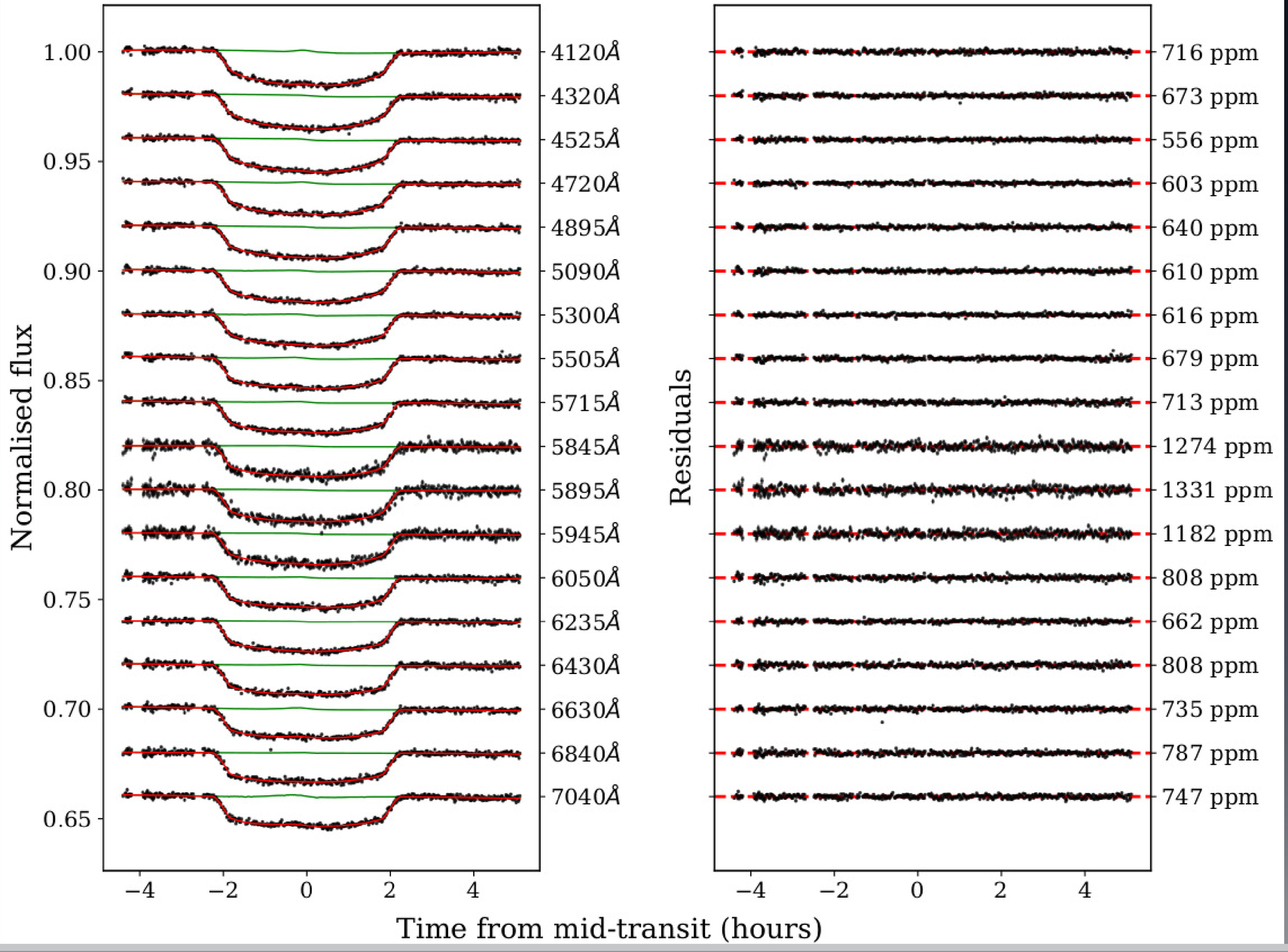
- 1 transit in August 2017 with NTT/EFOSC2
- Wavelength range 3900 - 7100 Å
- Long-slit spectroscopy with comparison star
- 27” slit width, 4.1’ slit length





White light curve



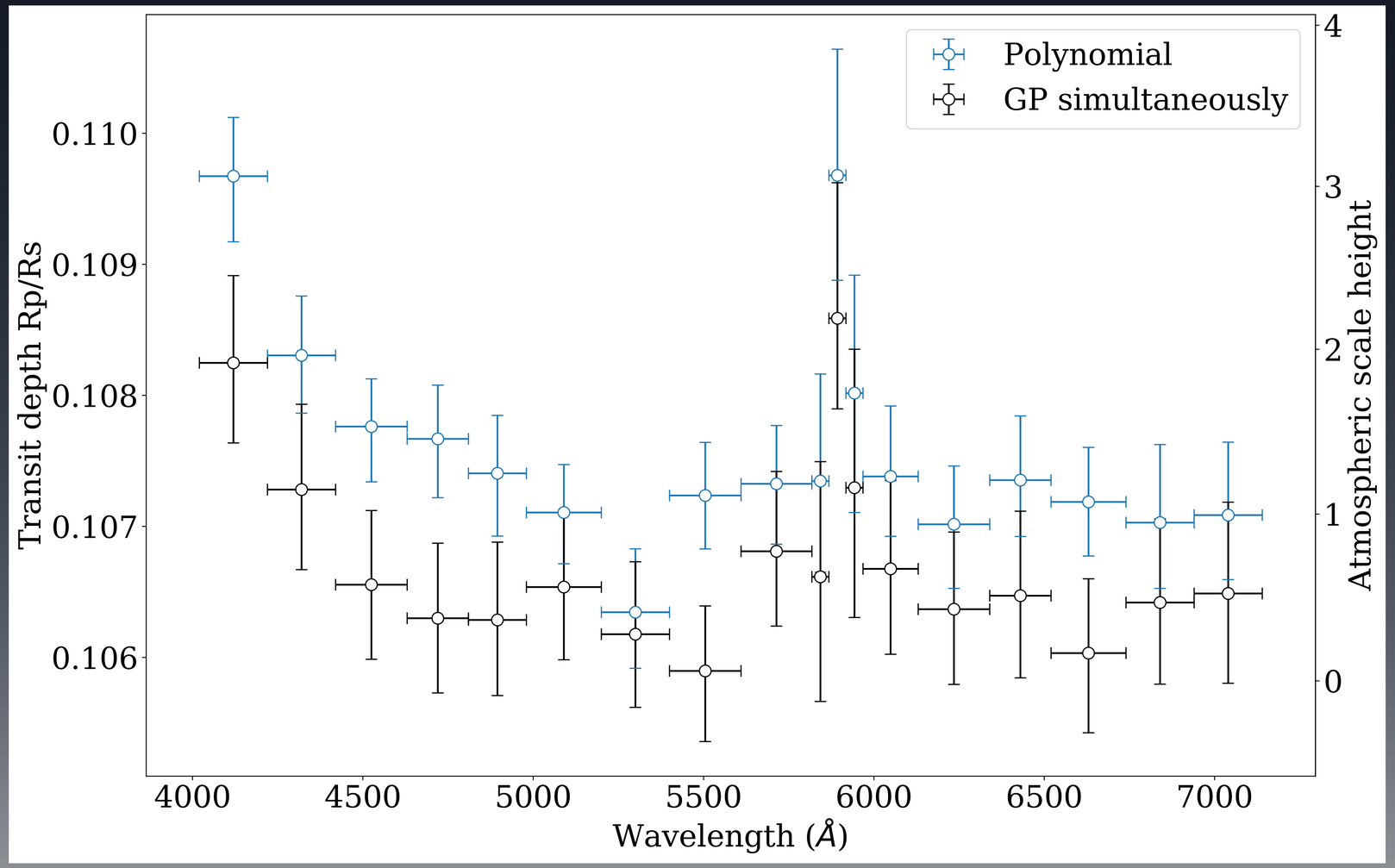


Spectroscopic Light Curves

- Simultaneous fitting of all spectroscopic light curves
- Two GP kernels
- Length scales of GP kernels are shared across all bins
- average of 128 ppm across ~200 Å bins

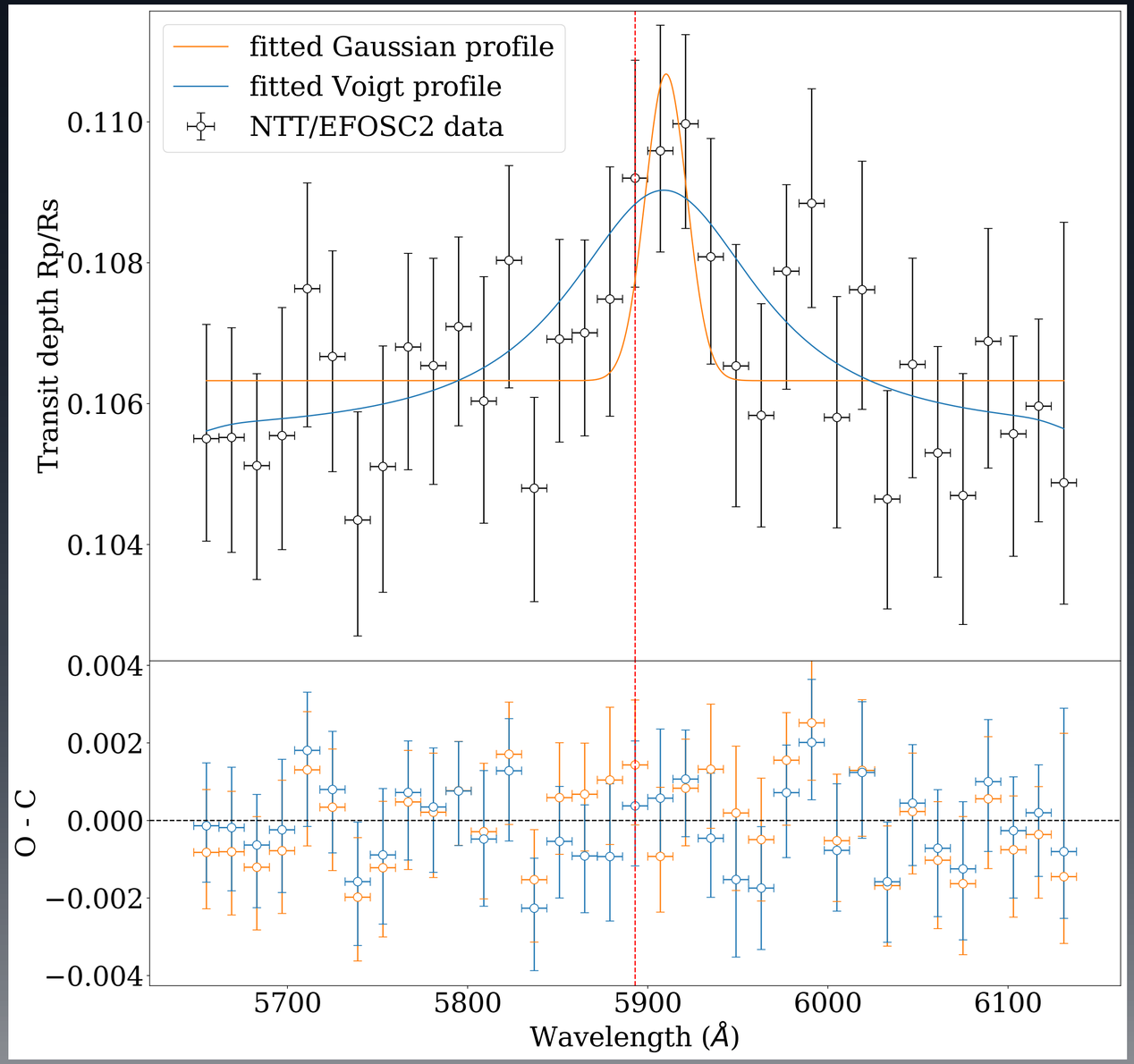
Transmission spectrum of WASP-94A b

- Two detrending methods show similar results
- Sodium feature
- Scattering slope, tentative evidence for super-Rayleigh slope (red line)



Sodium feature: broadened?

- Fitting Gaussian with instrumental resolution (27 Å) vs fitting Voigt profile
- Bayesian evidence favours Gaussian fit by $\Delta \ln Z = 1.7$
- Broad Na best fit: 78^{+67}_{-32} Å



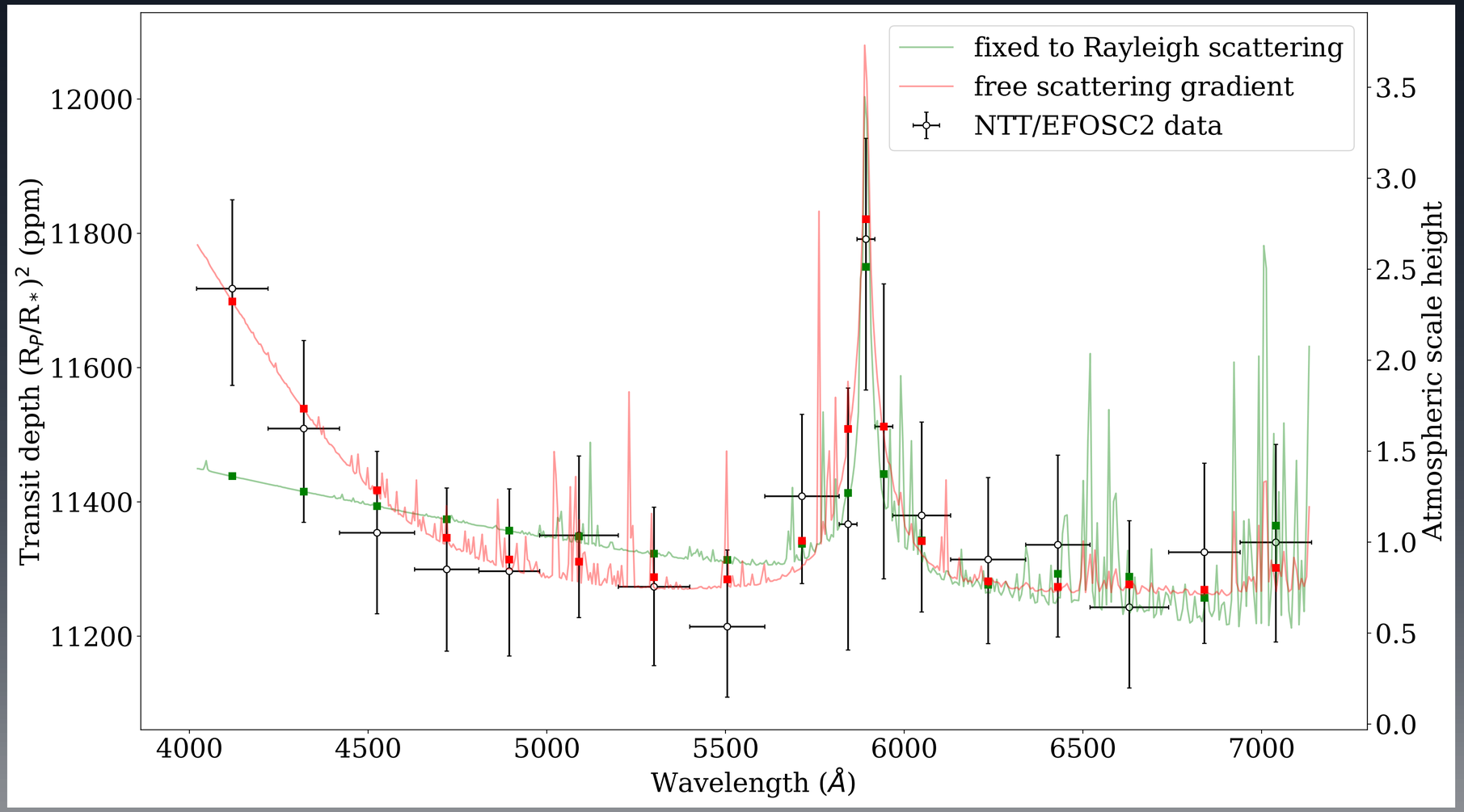
Scattering slope: super-Rayleigh?

PLATON: Zhang et al. (2019, 2020)

Consistent with

- model fixed to Rayleigh scattering ($\alpha = 4$)
- model with super-Rayleigh gradient ($\alpha = 13.6^{+4.4}_{-8.7}$)

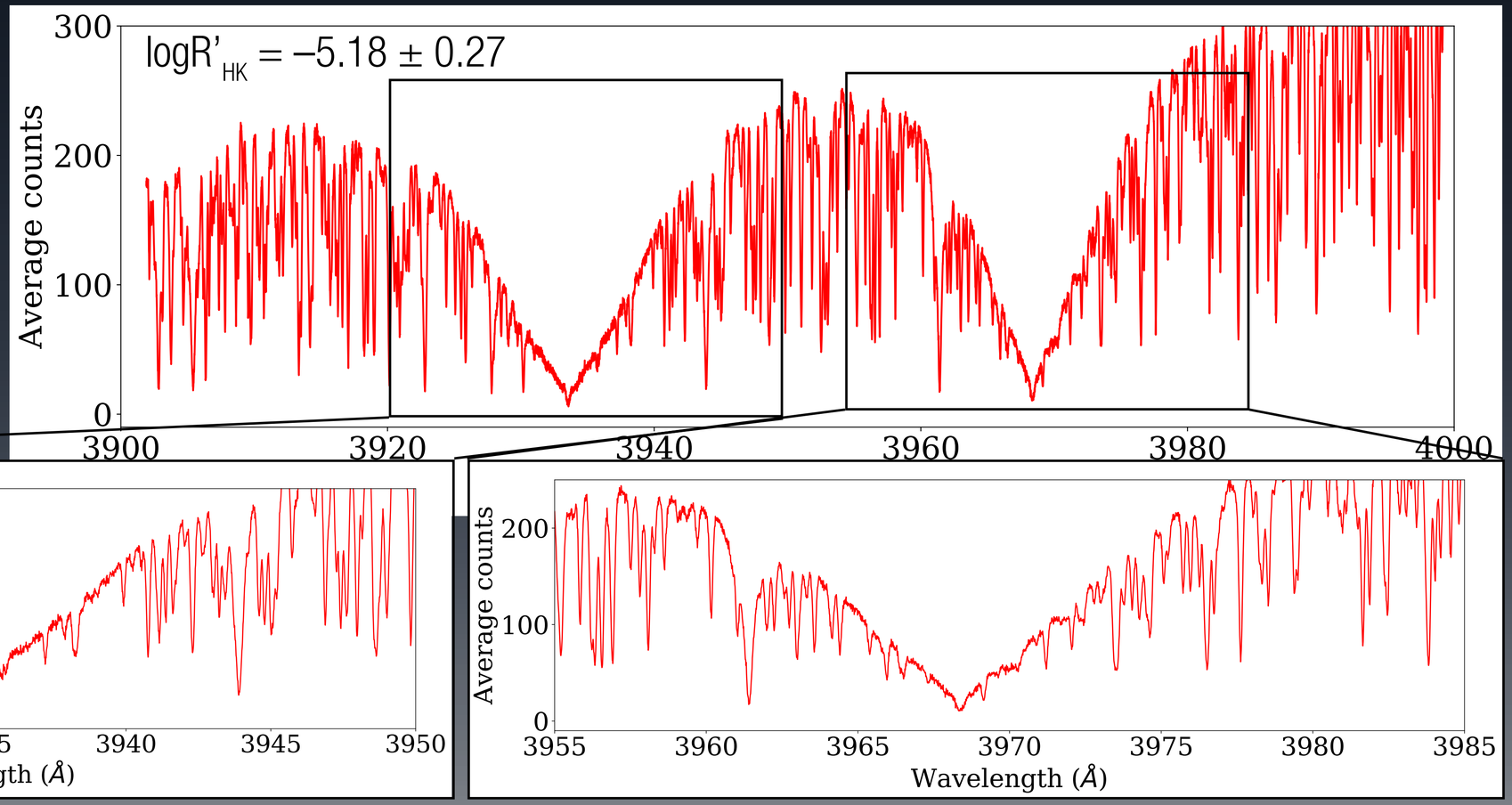
Bayesian evidence slightly favours enhanced slope



What about stellar activity?

[1] Rackham et al. (2019), [2] Haswell et al. (2020)

- late F type star, predicted 2 - 7% spots + faculae covering fraction [1]
- cannot account for enhanced slope



- might be viewed though removed planetary material absorbing the stellar emission? [2]

Conclusions

Ahrer et al., in prep.

- First transmission spectroscopy using NTT/EFOSC2
- First transmission spectrum for WASP-94A b
- Perfect conditions and simultaneous GP fitting allowed for optimising precision to an average of 128 ppm in ~200 Å bins
- Na feature detected, potentially broad
- Scattering slope, tentative evidence for enhanced slope
- Call H&K lines suggest absorption
- Optimal target for follow-up observations