
고등과학원(KIAS) & SDSS 한국과학자 그룹(KSG)
SDSS-KSG 하계 워크숍
▶일시 : 2005년 8월 22일 ~ 24일
▶장소 : 안면도

SPECTR

(Spectrophotometer for Transmission Spectroscopy of Exoplanet Systems)

observation of planetary transit systems

MYEONG-GU PARK (KYUNGPOOK NAT. U.)

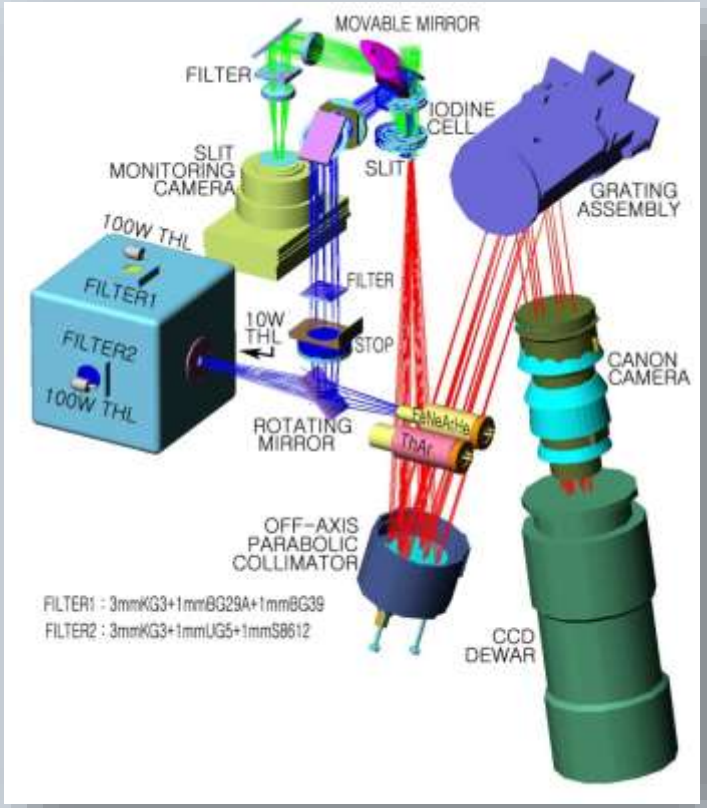
KNU: TAE-YANG BANG,

KASI: KANG-MIN KIM(PROJECT ENGINEER), YEON-HO CHOI, CHAN PARK, INWOO HAN, BYEONG-CHEOL LEE, UEEJEONG JEONG, BE-HO JANG, JEONG GYUN JANG, SANG-MIN LEE

KONGJU: JAE-RIM KOO

Exoplanet Studies with BOES

- Bohyunsan Observatory Eschelle Spectrograph + 1.8m
- Precision RV observations of giants and bright stars
- K-EXO Collaboration
  - KASI: Byeong-Cheol Lee, Kang-Min Kim (BOES), Inwoo Han (RVI2CELL) +
  - KNU: MGP +
- Achievement
  - 35 exoplanets out of 700 stars over 16 years
    - Mostly evolved giant stars
  - Stellar oscillation, rotation, and surface activity

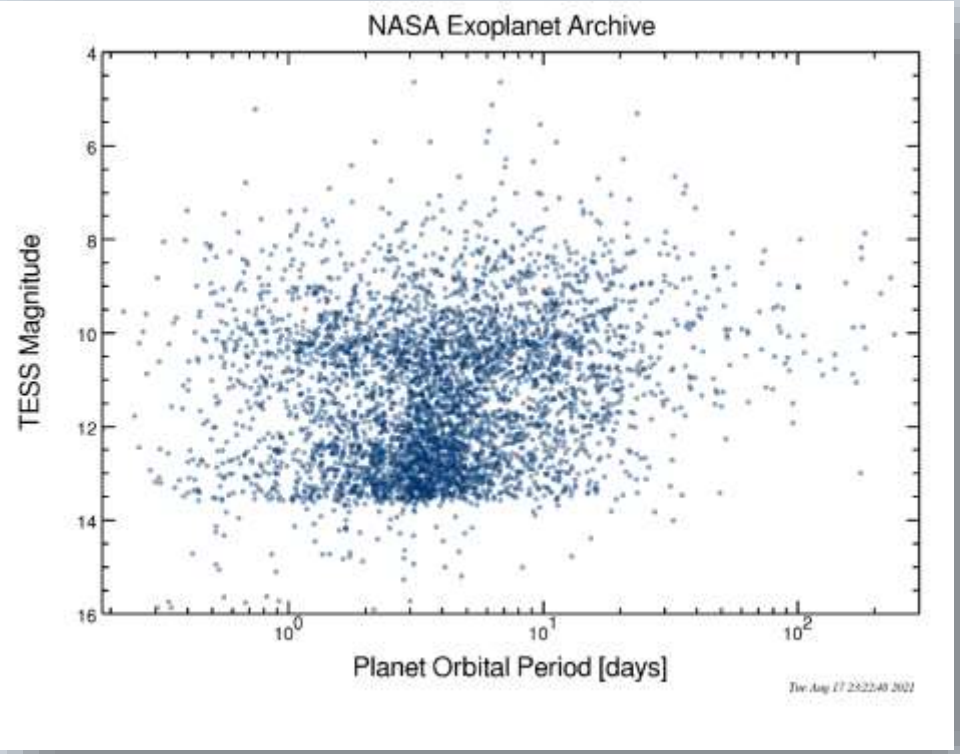


From discovery to the characterization of planets

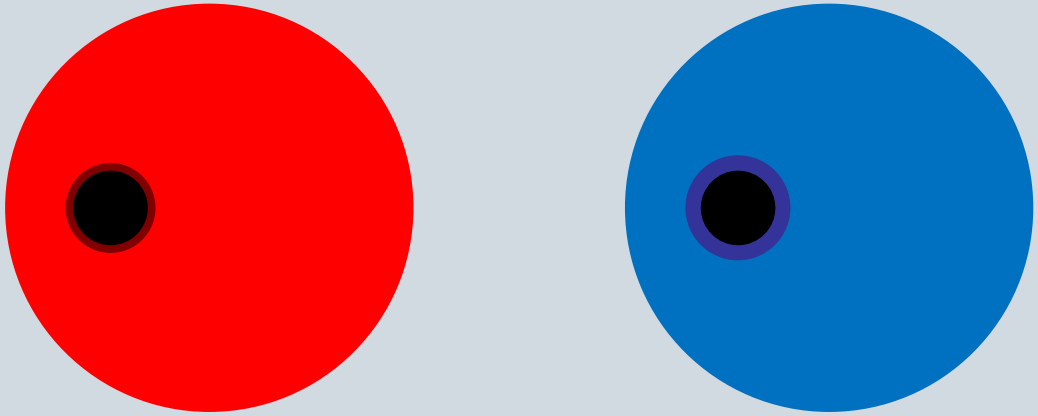
Density: rocky or gaseous
- Radius – Transit observation
- Mass – RV observation

Exoplanet atmosphere
- Composition of exoplanet atmosphere
- Biomarker from earth-like planets within habitable zone
  - Key science of GMT+G-CLEF

Bright-enough targets available, e.g, from TESS



Transmission Spectroscopy (투과분광)



- Brightness change during the transit depends on the wavelength.

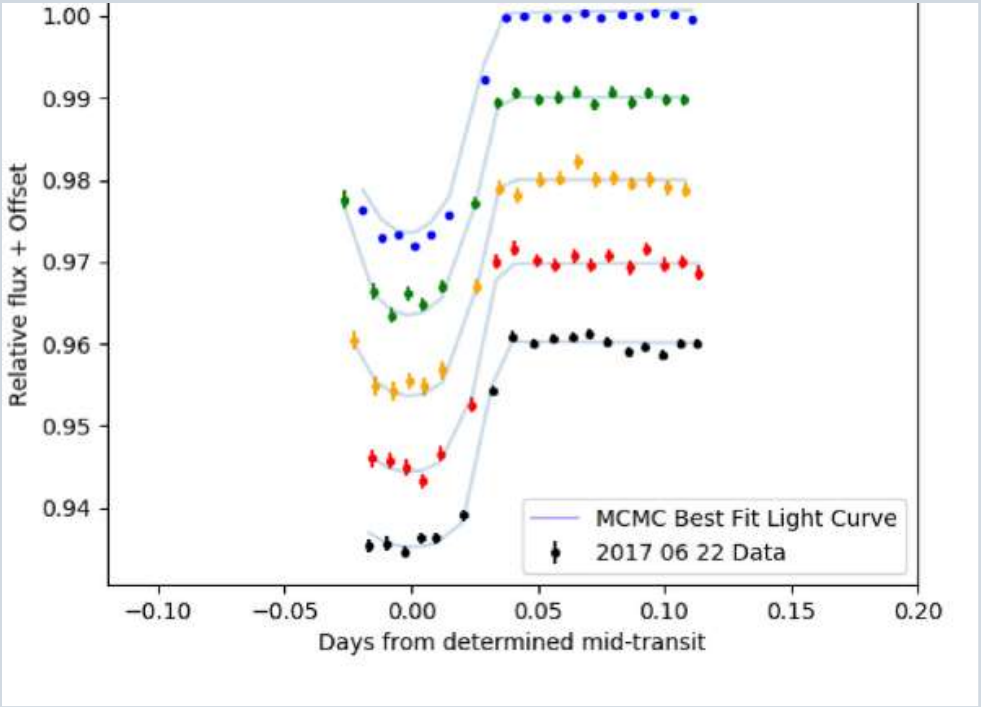
- Transmitted spectrum reflects the composition of the exoplanet atmosphere.

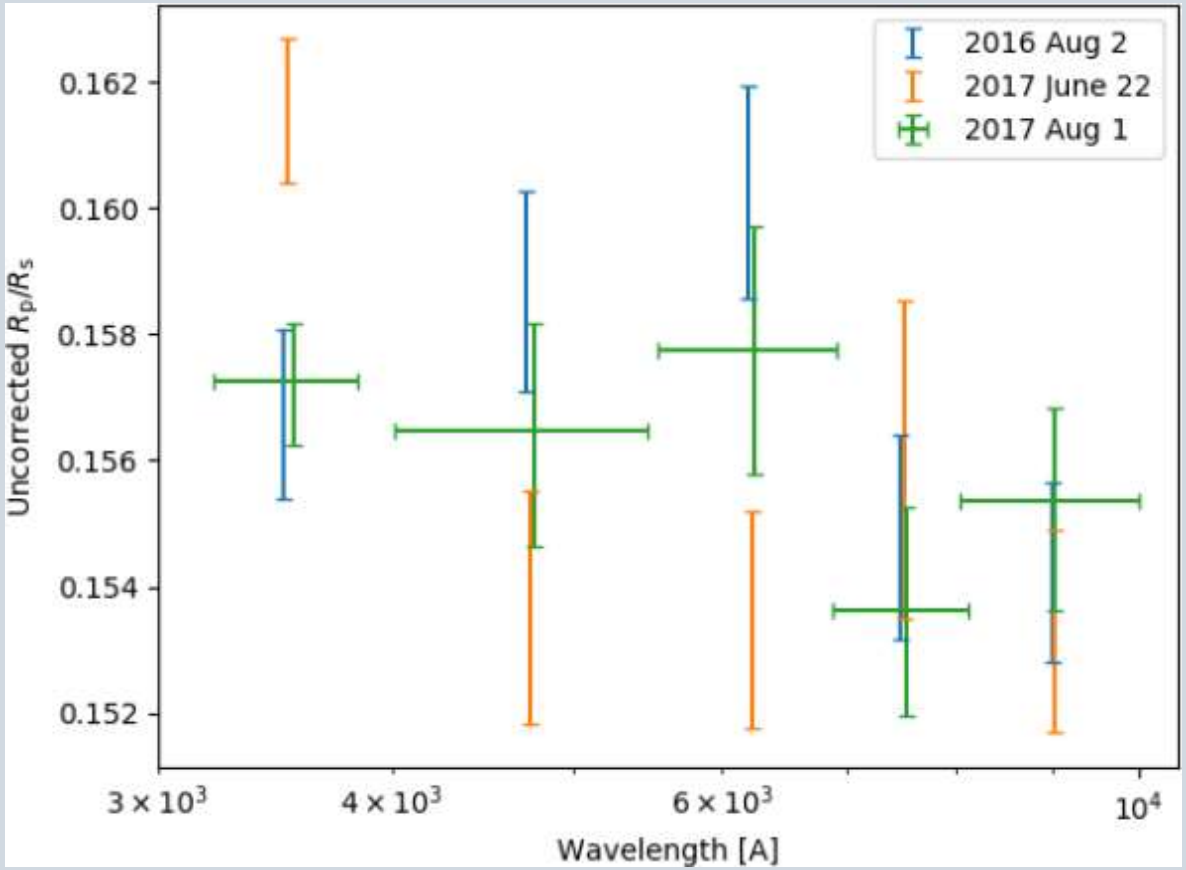
- Precise spectrophotometry required.

Multi-Band Transmission Photometry

Kasper et al. (2019)

- A transmission spectrum of HD 189733b from multiple broad-band filter observations
- Wyoming Infrared Observatory
- 2.3 m telescope
- Sloan u', g', r', I', z'
- 5 comparison stars



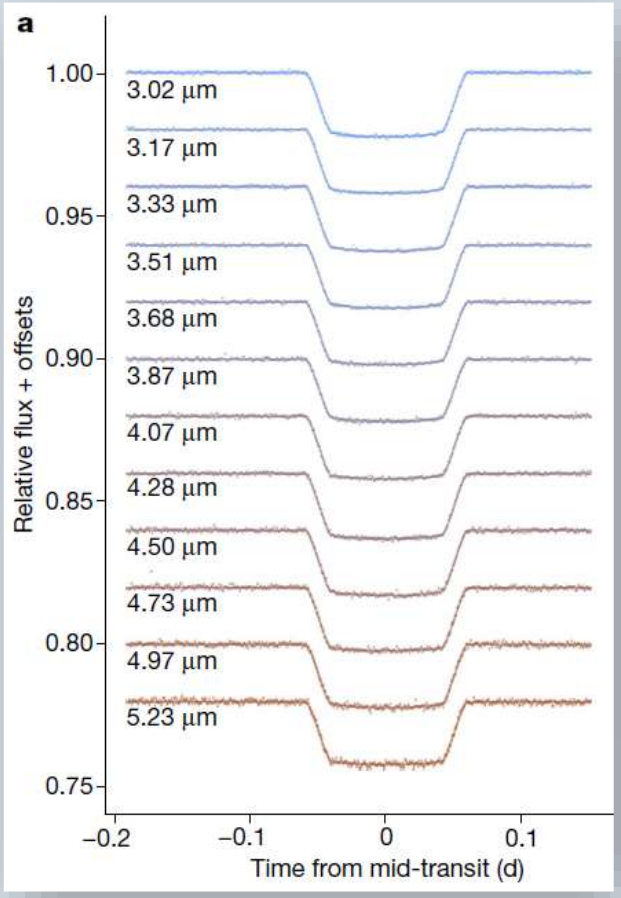


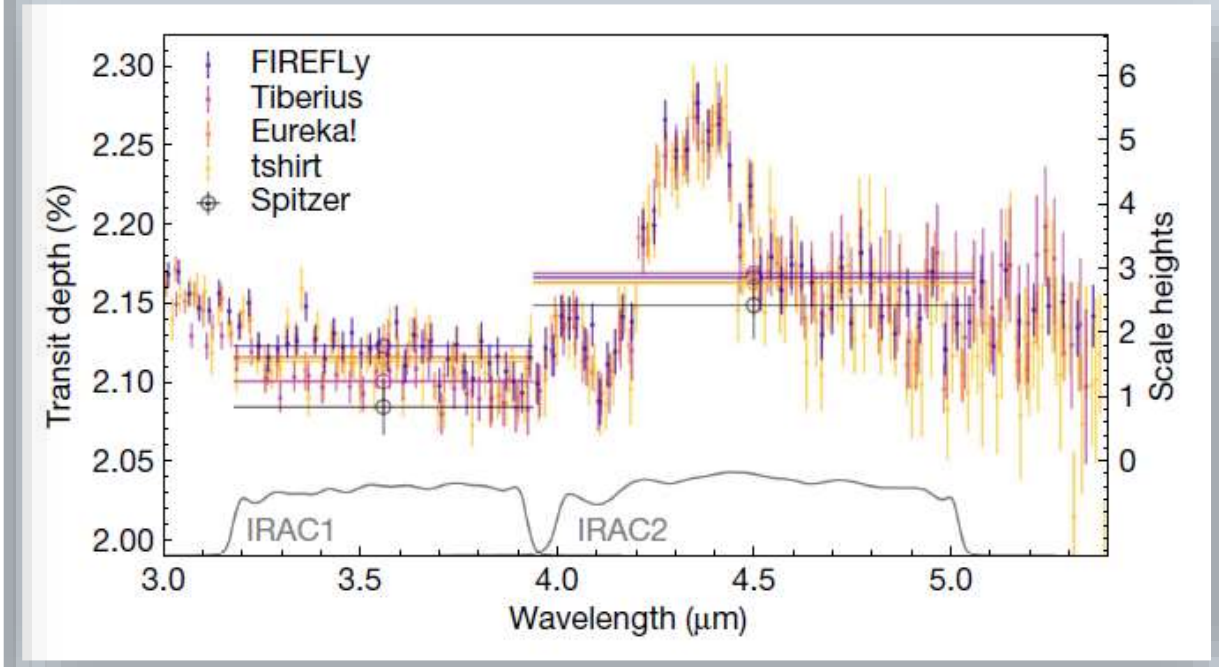
Uncorrected for star spots

Kasper+ 2019

$\delta(R_p/R_*) \sim 0.002$

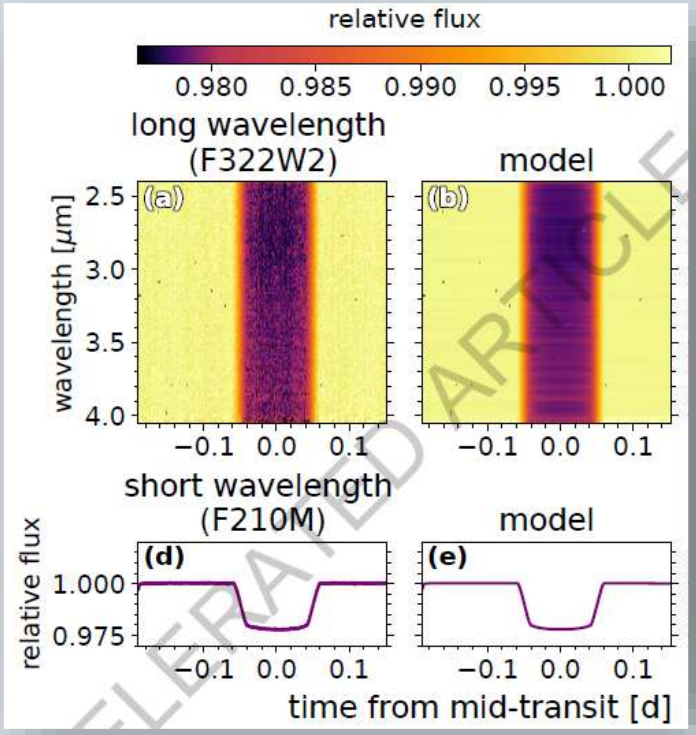
JWST NIRSpec on WASP-39b

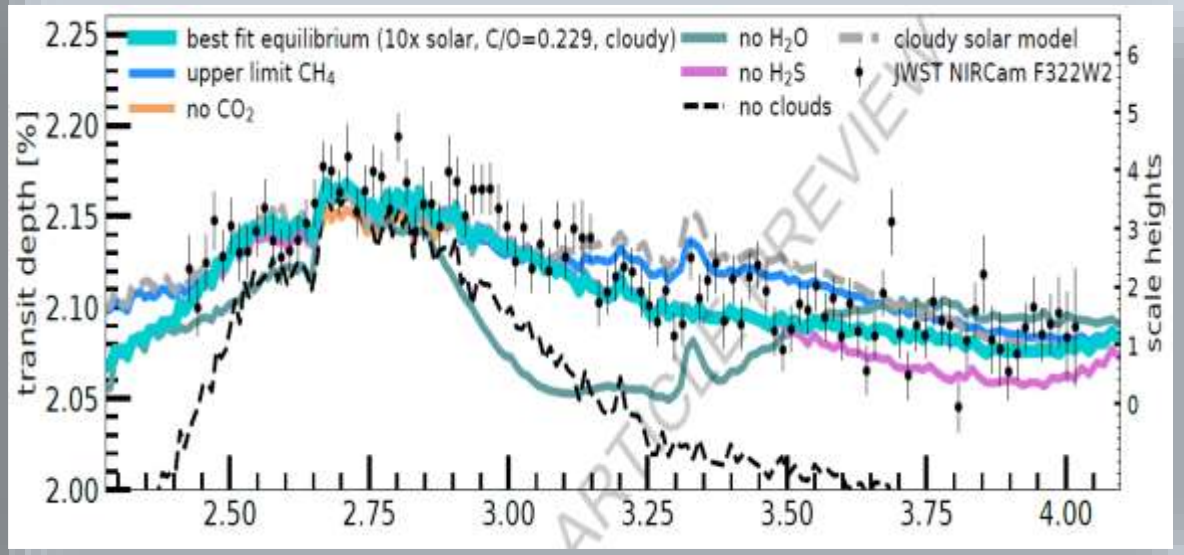




JWST Transiting Exoplanet Community Early Release Science Team 2023 Nature

JWST NIRCam on WASP-39b

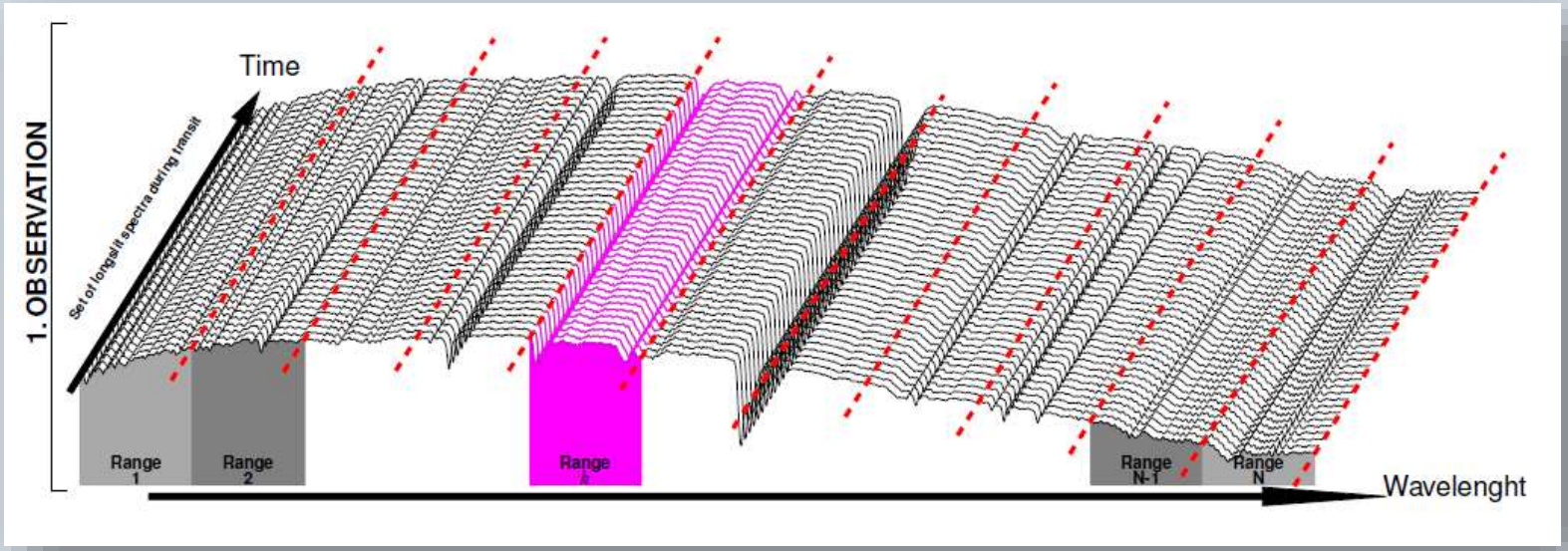




Ahrer+ 2023 Nature

TR Spectroscopy with 1~2 m Telescopes

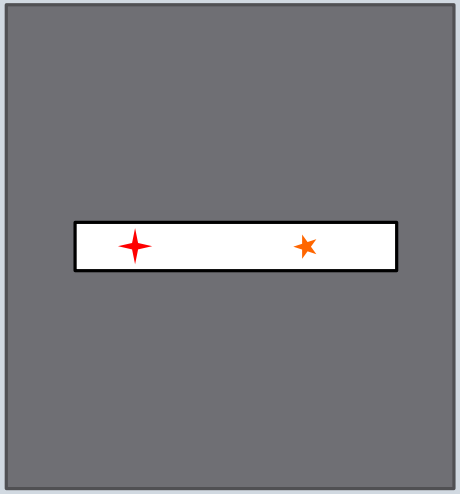
Time series photometry with low dispersion spectral observation during and off the transit



G. Valyavin

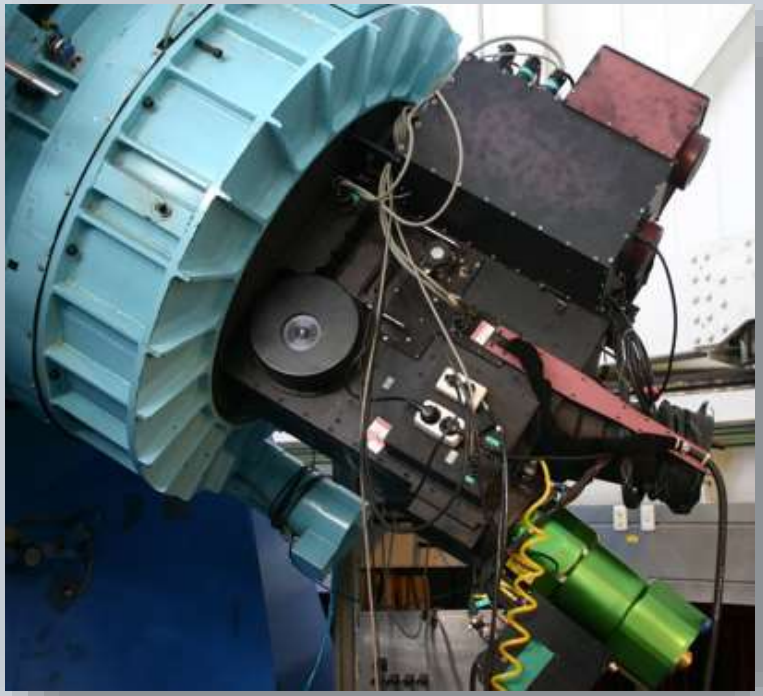
Design Requirements

- Wavelength coverage: as wide as possible
- Very wide slit width to minimize the seeing induced variation
- Low to medium spectral resolution
- Very long slit length for simultaneous observation of target and comparison star
- Direct imaging capabilities

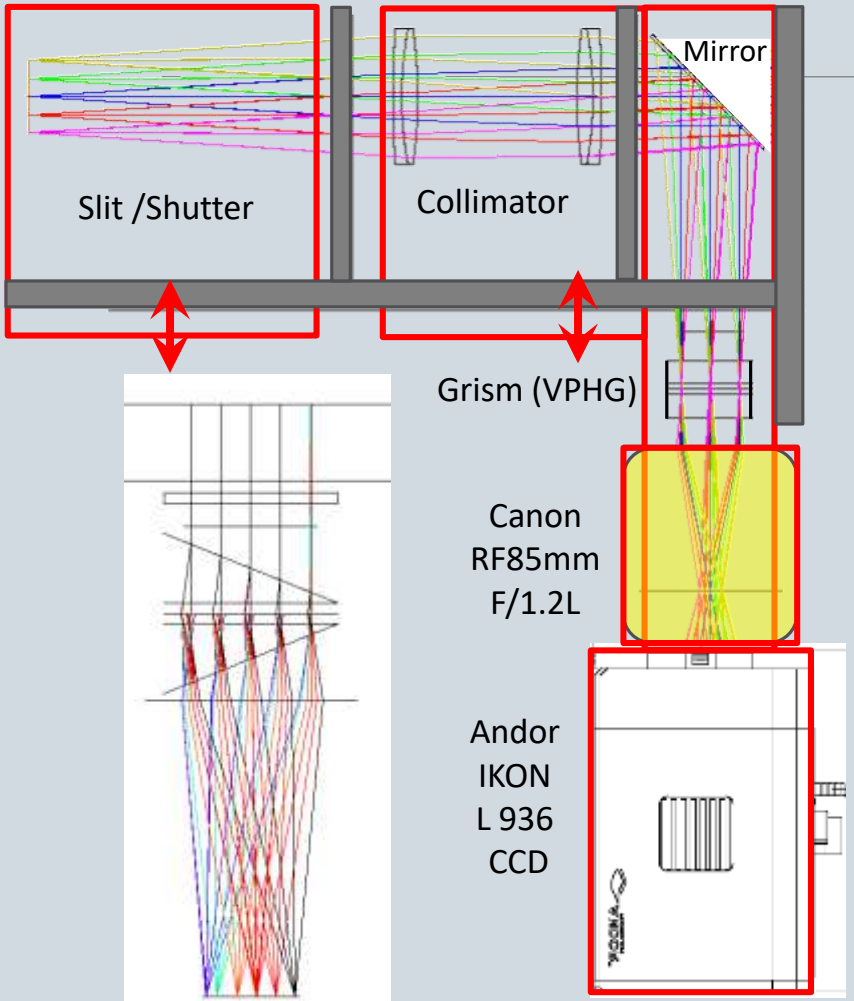


Design Limitations

- Limited space behind the 1.8m telescope
- Auxiliary systems as in CIM needed
  - Calibration lamps
  - Slit monitoring camera
  - Auto-guiding system
- Mounting/demounting CIM too costly



Optics



Wavelength : **380-685**nm
Length: 401.7mm + 533.7mm
FOV : 10 x 4.6 arcmin.
Collimator : **f280mm**, Optosigma DBL80-500 x 2ea
Imaging Lens : Canon RF **85mm** F/1.2L
CCD : Andor IKON L936 CCD(13.5µmx2048^2)
Φ(pupil) : **35** mm
Grism : Wasatch **900** g/mm, 50 x 50 mm, Blaz.λ@526.1nm
Apex Angle of Wedge Prisms : 25.3 deg.
Cal Optics, guiding, slit monitoring in CIM

Plate Scale : 21.3 µm/arcsec (4px/2.5", 0.62"/px)
Resolution: **R > 400** (RS ~ 2000 ["])

No Rotational (tilting) VPHG function.

* Storage Container : Test & Alignment

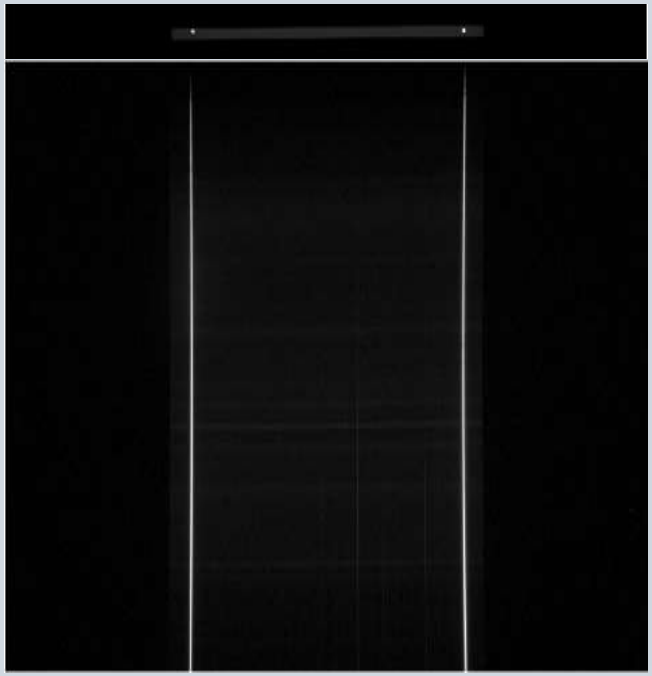
Two Cartridge System

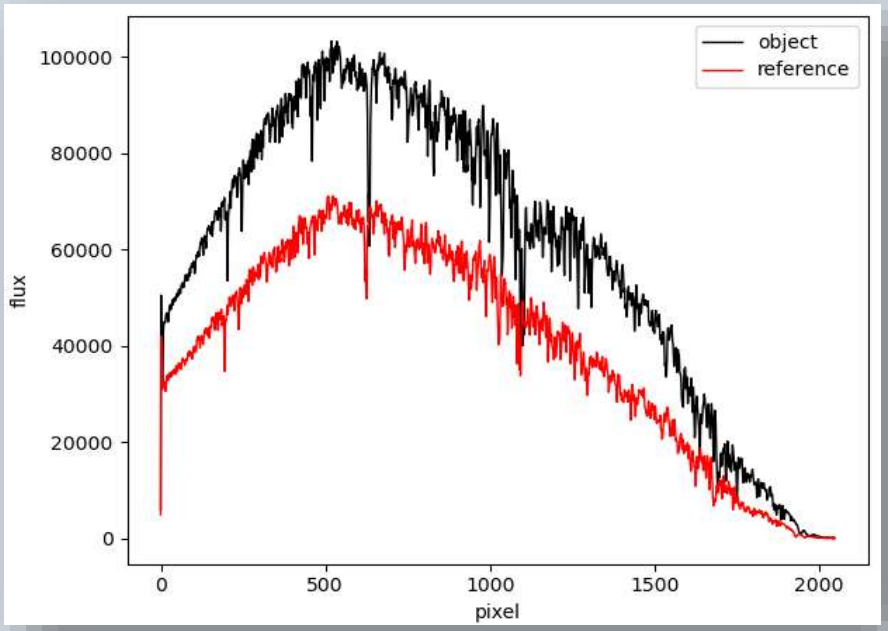
- Slit assembly
- Collimator assembly
- Mirror assembly
- Grism assembly
- Imaging lens assembly
- CCD assembly

System Adjustment & Test Observation

- 20 days: September & October of 2021
- System check & adjustment
- Test observation
  - 6 TESS transit systems

HD 189733

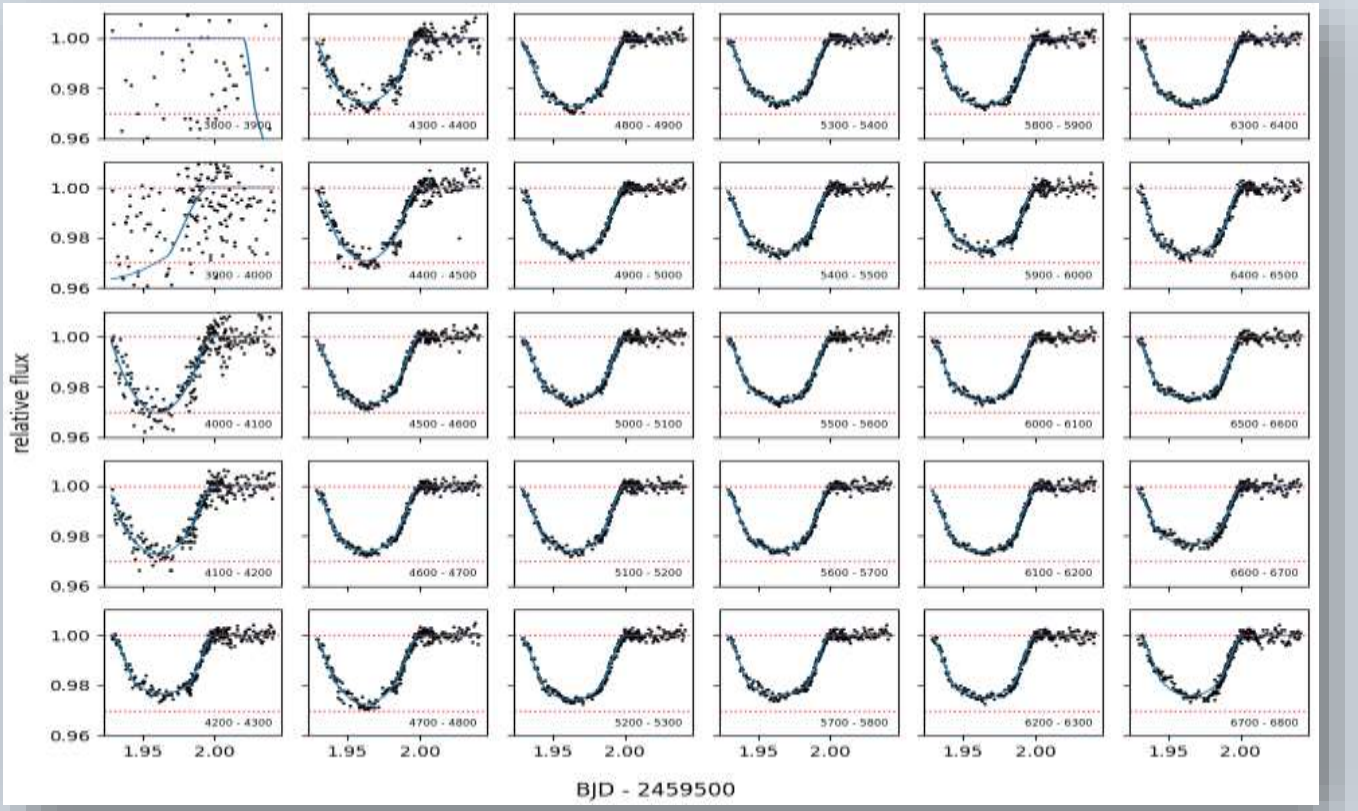




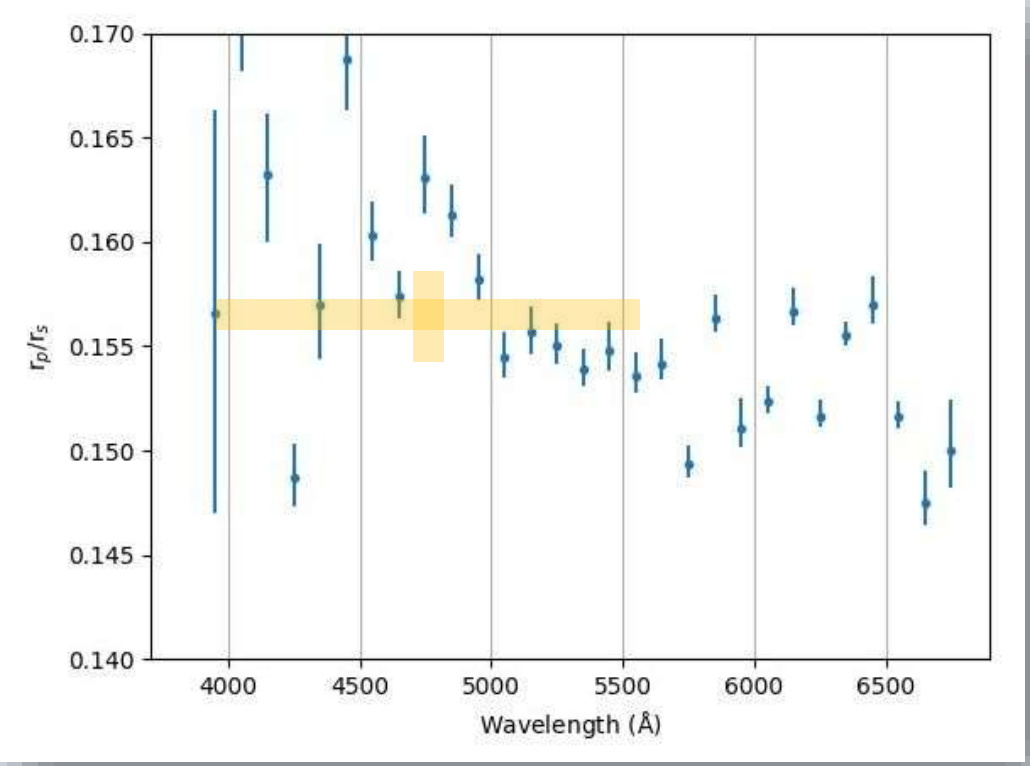
8.7′

V = 7.7, 8.1

- Transit fits (PyTransit) for each 100 Å band



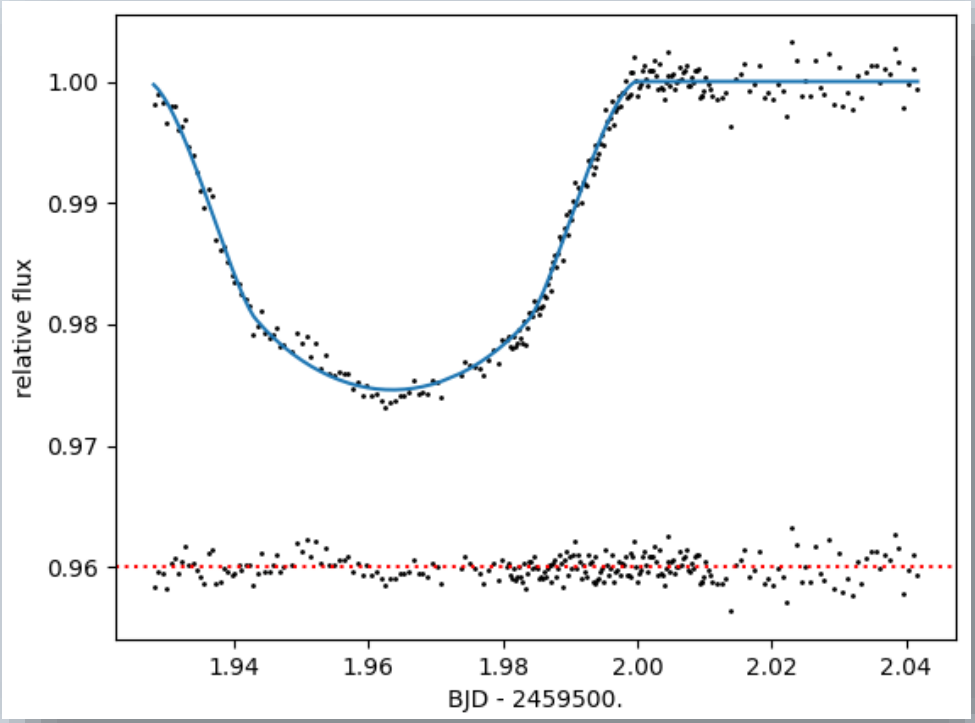
- Planet radius spectrum



$\delta(R_p/R_*) \sim 0.001$

Kasper+ 2019

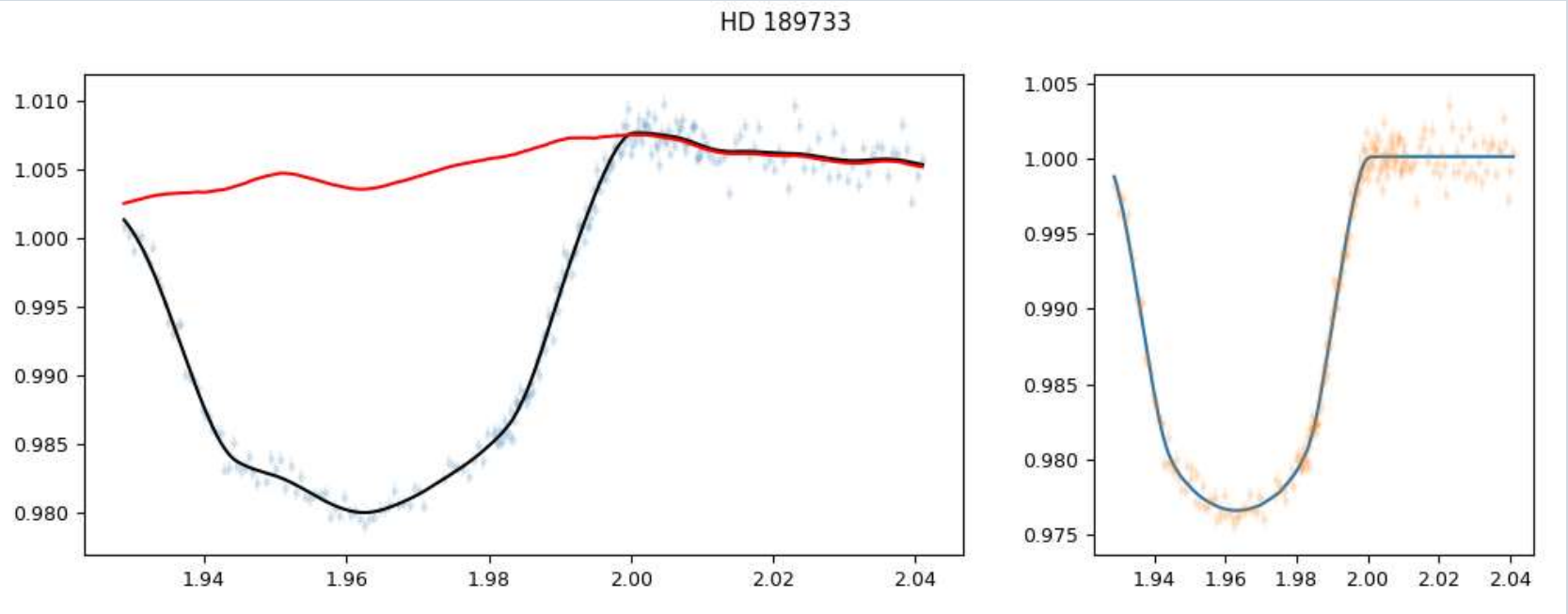
- Photometric accuracy



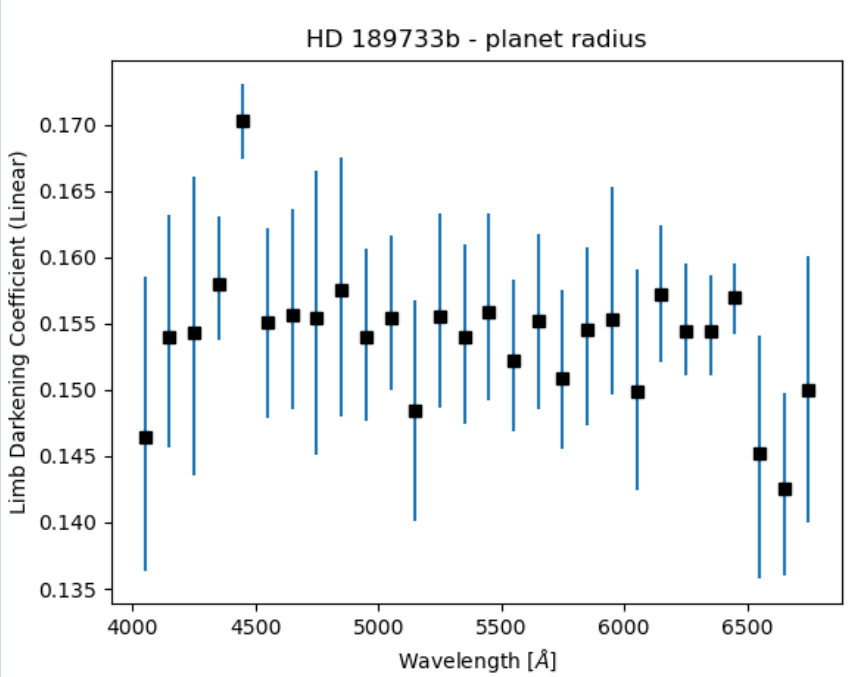
STD of 1.2 mmag

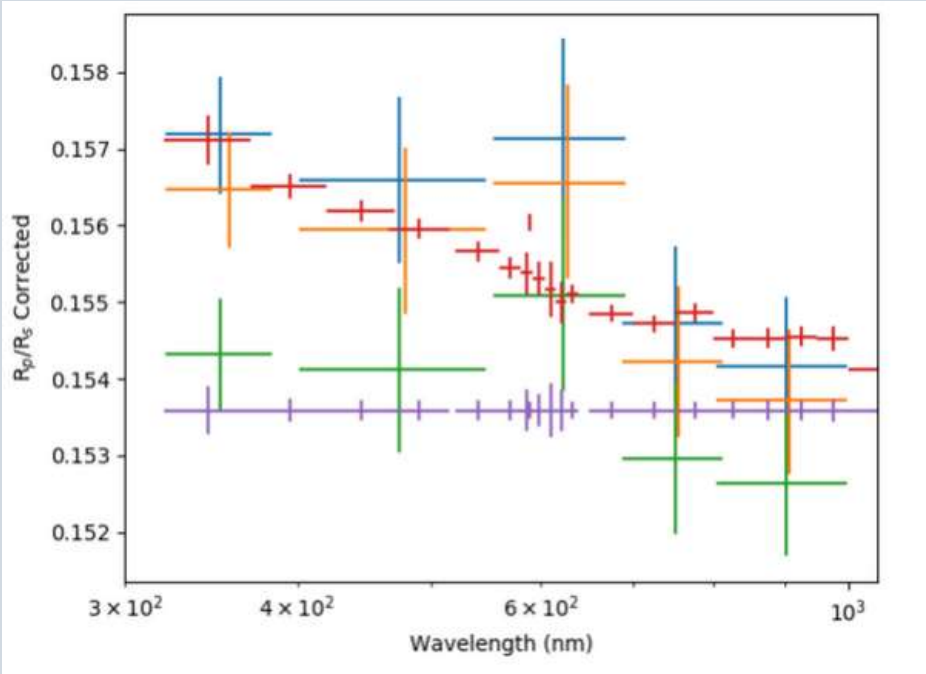
Gaussian Process

Joint analysis of exoplanetary transits & RVs
Juliet



HD 189733b





Kasper et al. 2019 MNRAS

Qatar-8

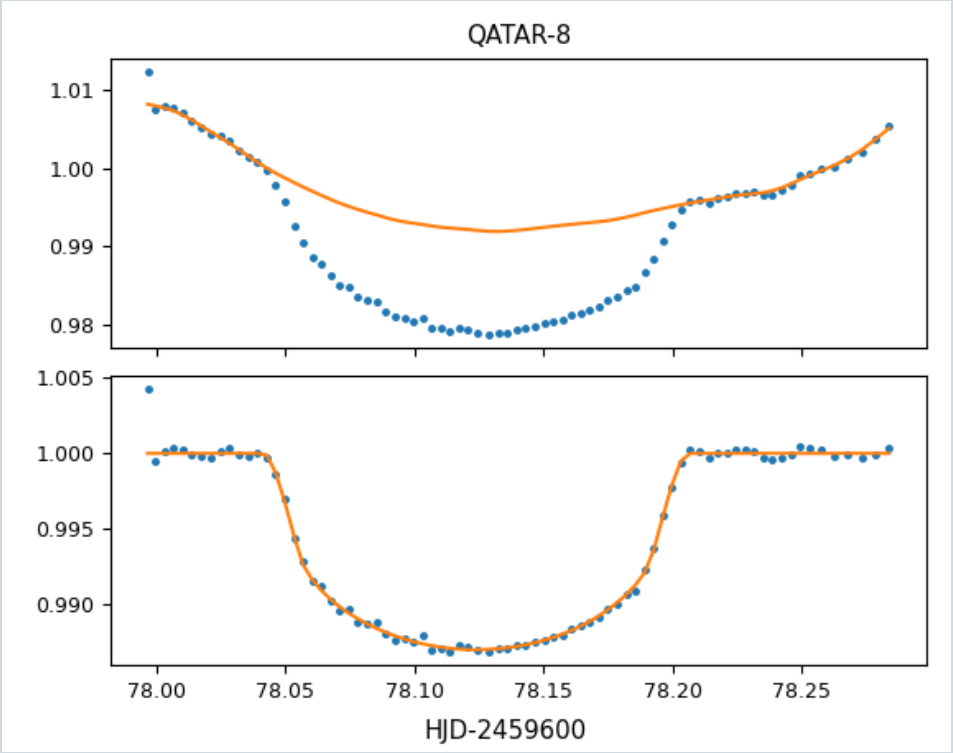
2022.04.08 11:55 - 18:44 (UT)

V = 11.7

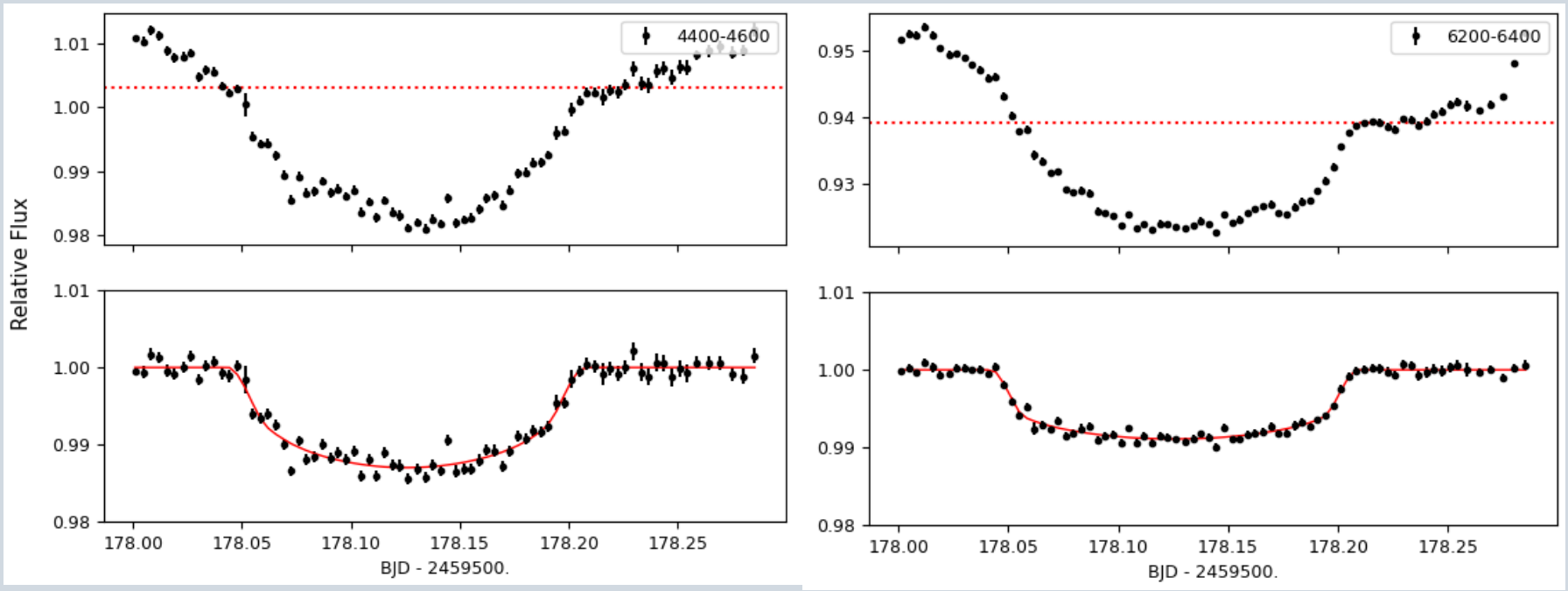
a = sma/r_* = 7.911
p = r_p/r_*= 0.100
b = 0.098
i = arccos(b/a) = 89.29°

Primary Transit Parameters:		
T_C	Time of transit (BJD_{TDB})	2458210.83980 ± 0.00085
R_P/R_*	Radius of planet in stellar radii	0.1005 ± 0.0008
a/R_*	Semimajor axis in stellar radii	7.761 ± 0.100
i	Inclination (°)	89.29 ± 0.70
b	Impact Parameter	0.096 ± 0.093
T_{14}	Total duration (days)	0.1678 ± 0.0017

Alsubai et al. 2019



Qatar-8



Qatar-8b

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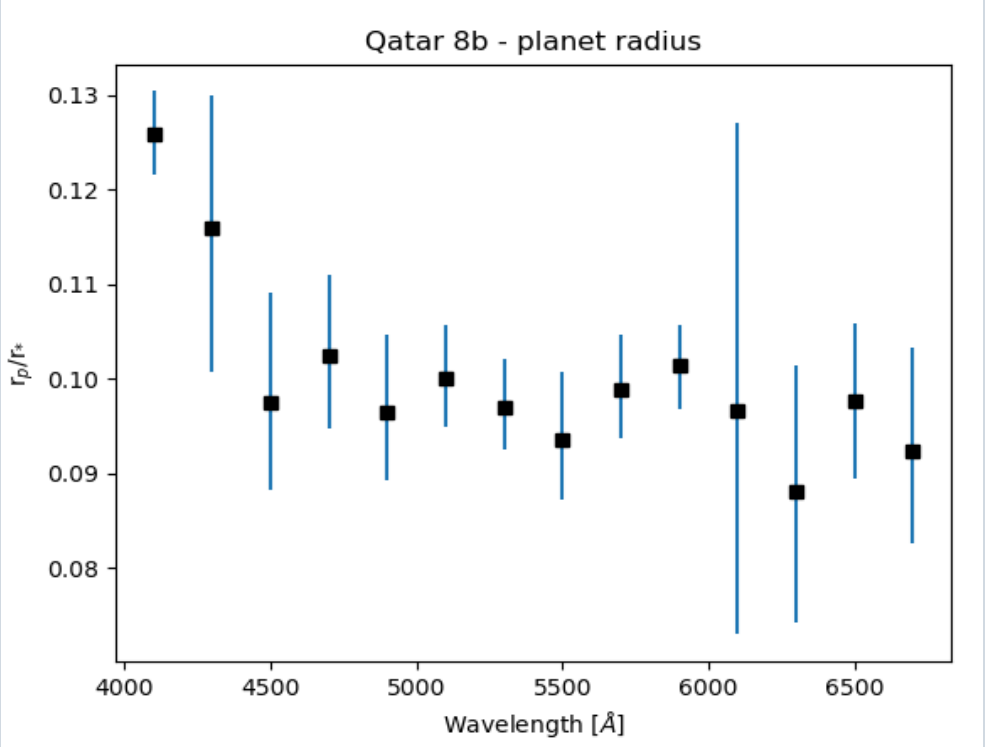
Alsubai et al. 2019, AJ



SPECTR

- Wide FOV, multi-purpose low-resolution spectrophotometer
- Direct view
- FOV: 10 x 4.6 arcmin
- VPH grism
- Wavelength: 380 – 685 nm
- Resolution: R > 400 (RS ~ 2000 [“])
- Slit widths: 1.4“, 2.0“, 2.8“, 4.0“, 6.0“, 9.0“, 15“, 25“
- Andor iKon L936 CCD (2k x 2k)