The ExoClock Project

Ground - based exoplanet observations in support of the ARIEL space mission

Anastasia Kokori

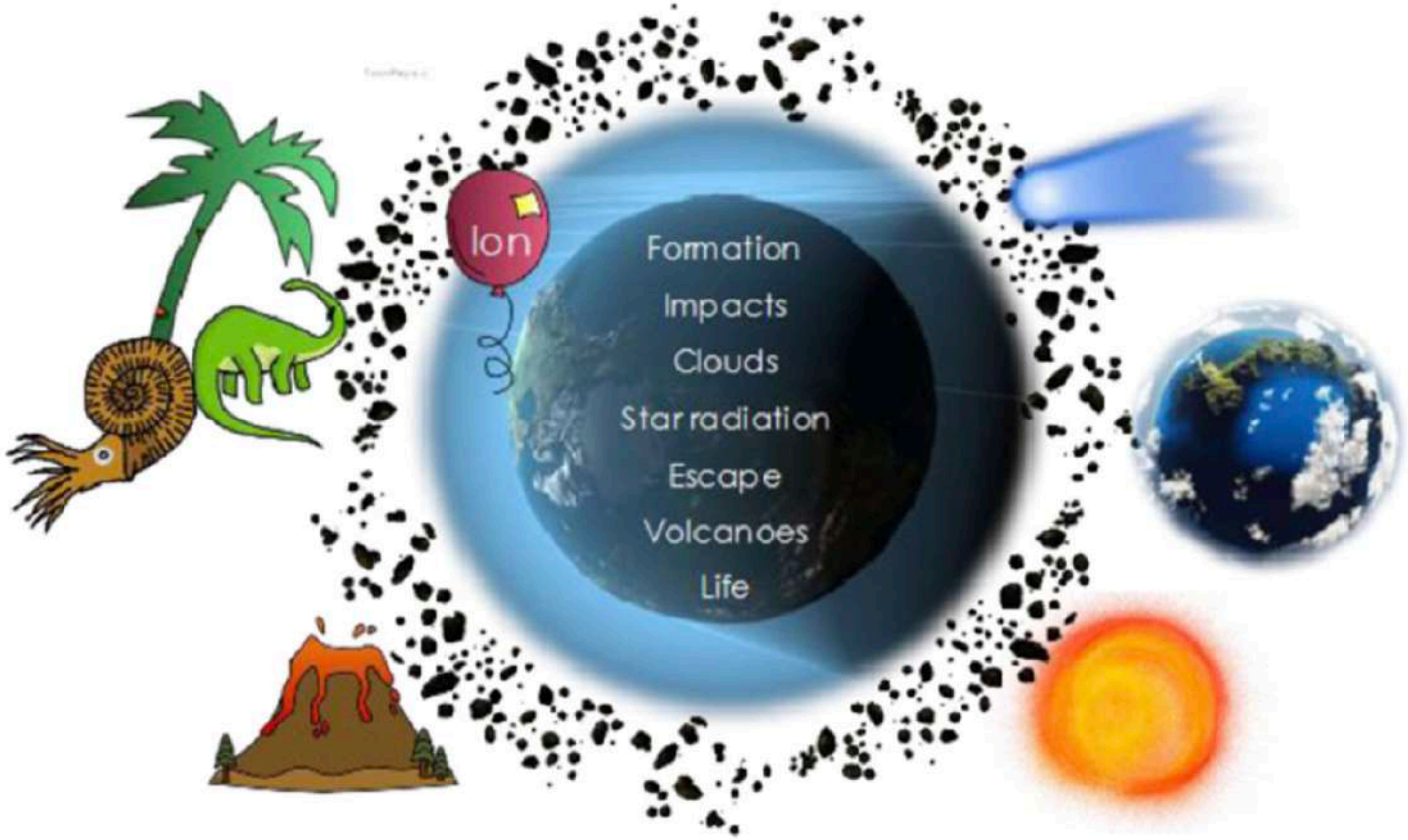
UCL, Birkbeck & Royal Observatory Greenwich

ARPS meeting, 29th September 2019

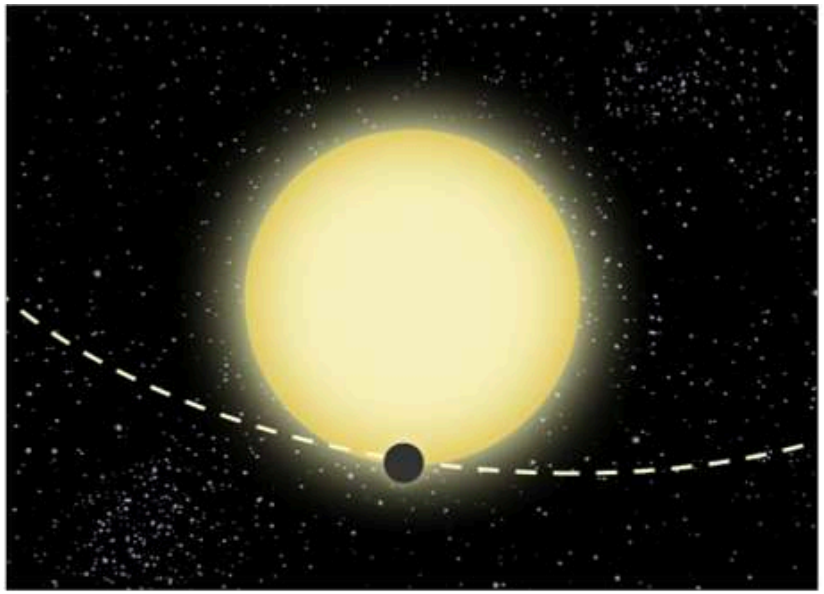
ARIEL space mission

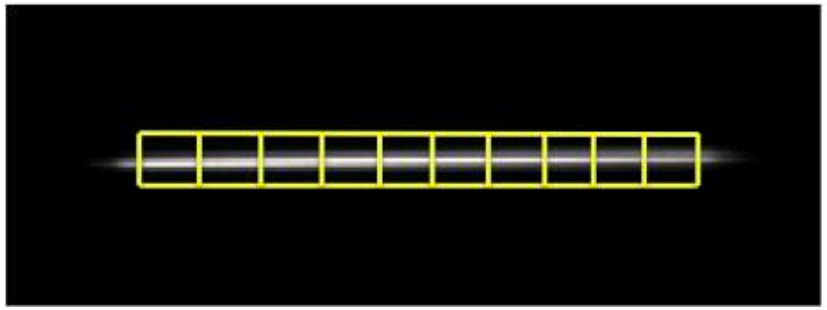
- ESA medium (M4) mission: Launch 2028
- Telescope aperture: 1 m
- Spectrograph
- Wavelength coverage: 0.5 - 7.8 μm
- Key science question:
  How chemically diverse are exoplanets?
- Science goal:
  Observe ~1000 exoplanet atmospheres

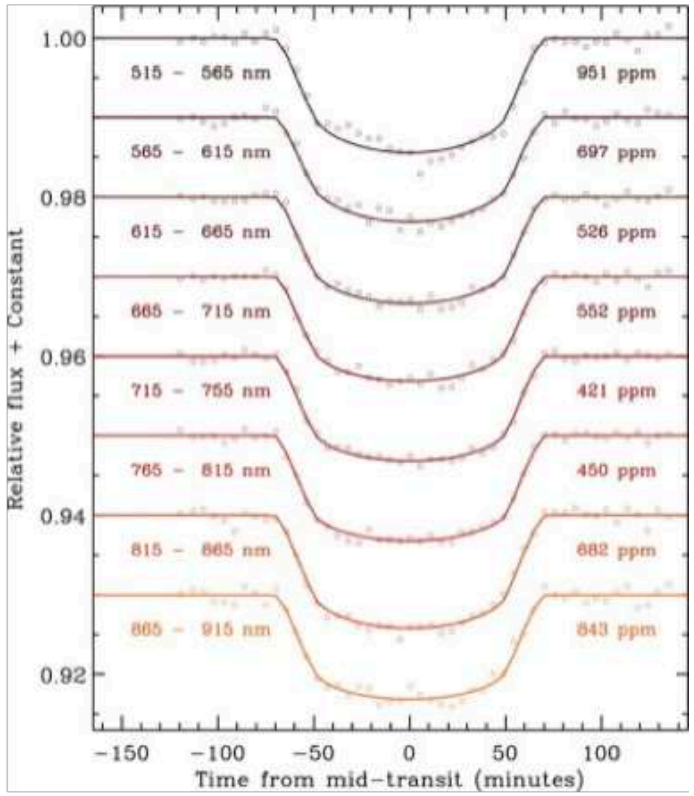
Importance of the atmopshere



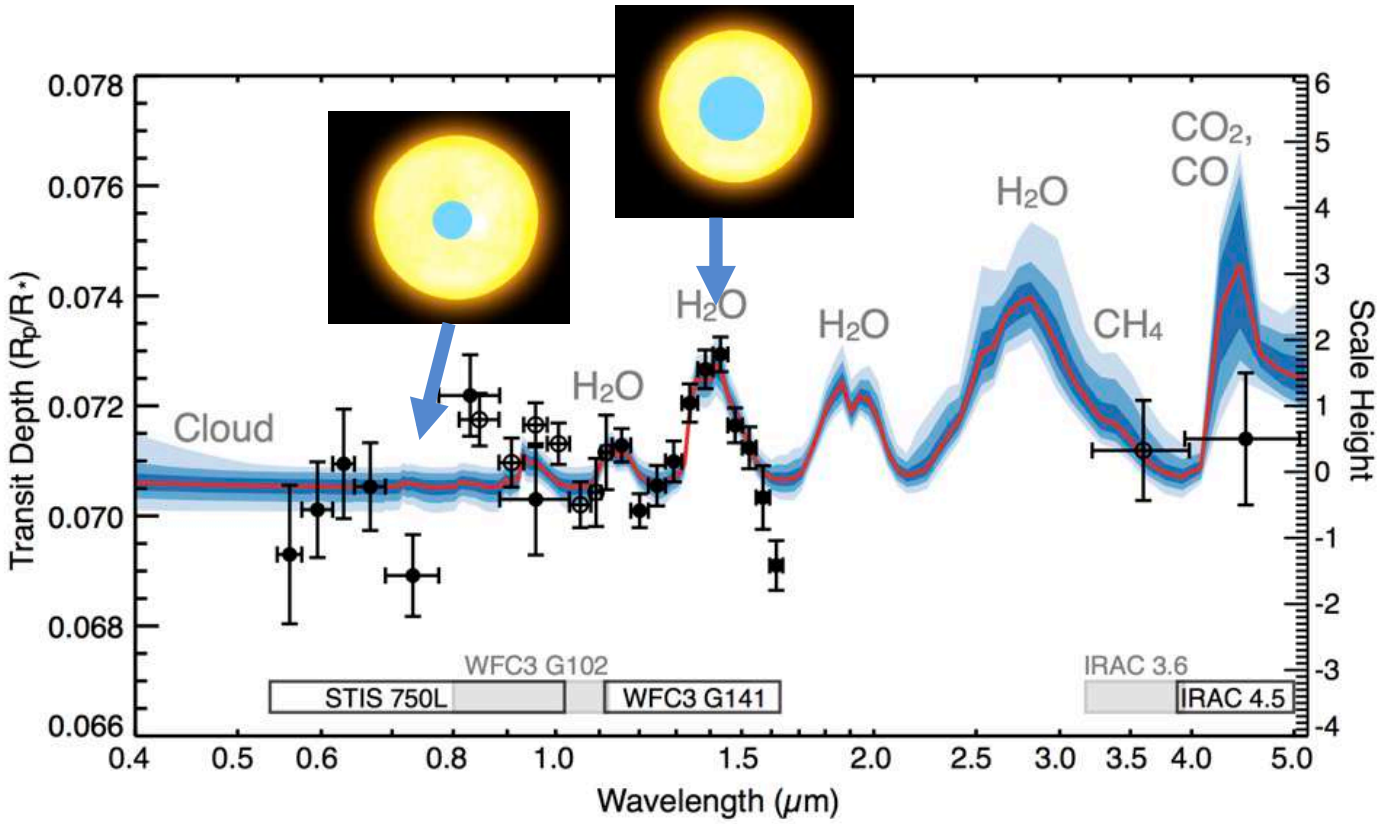
Transit spectroscopy





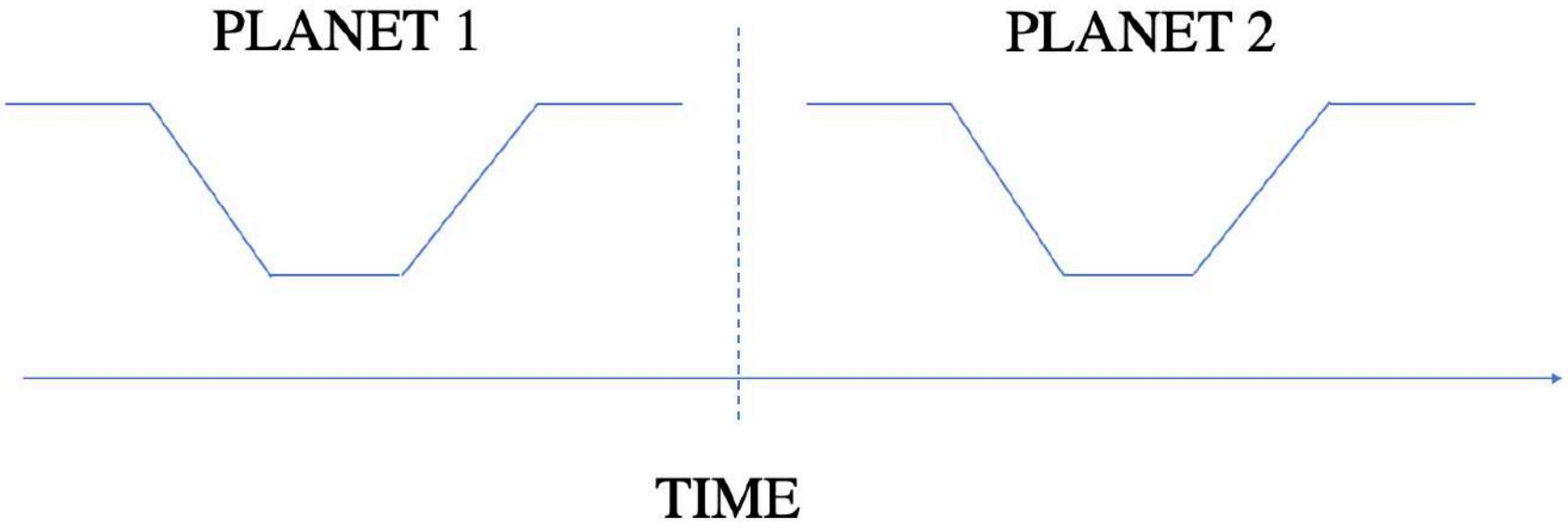


Transit spectroscopy

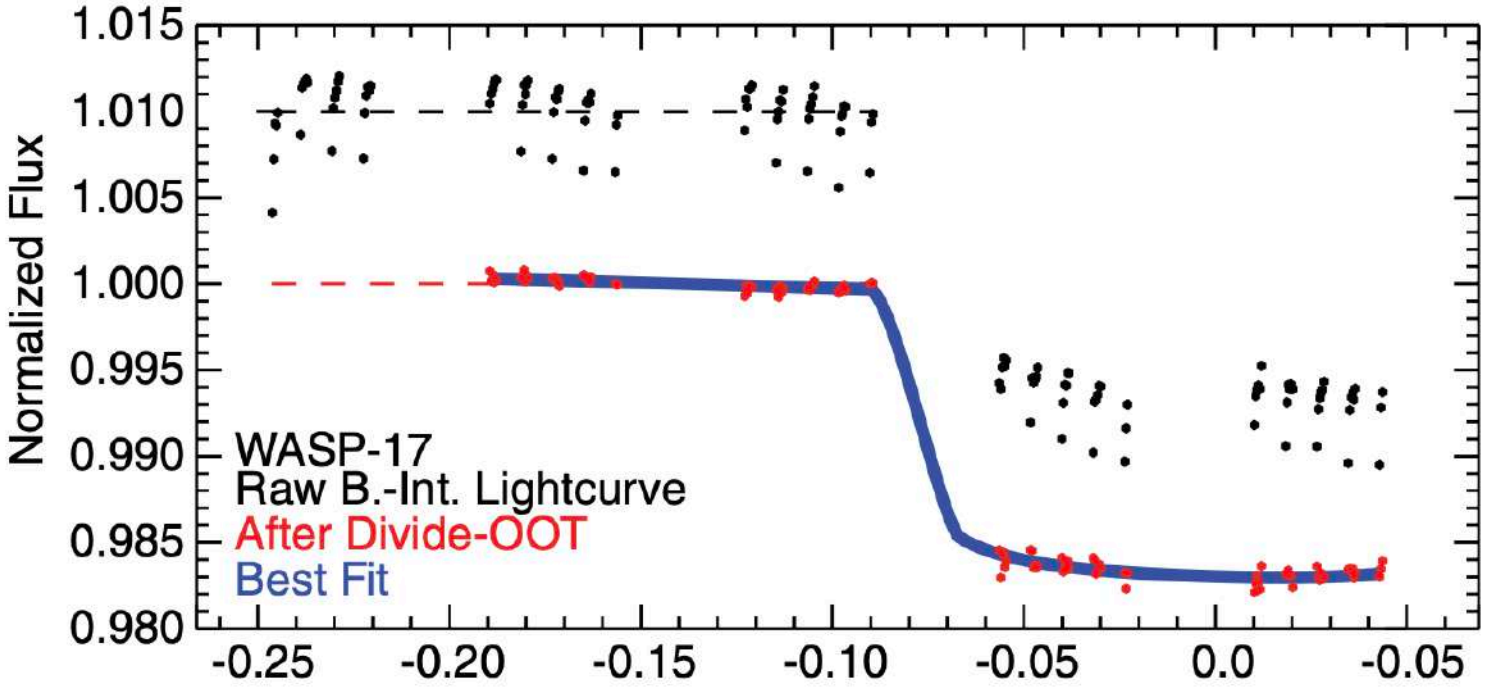


Wakeford et al. 2017

Time-critical



Time-critical



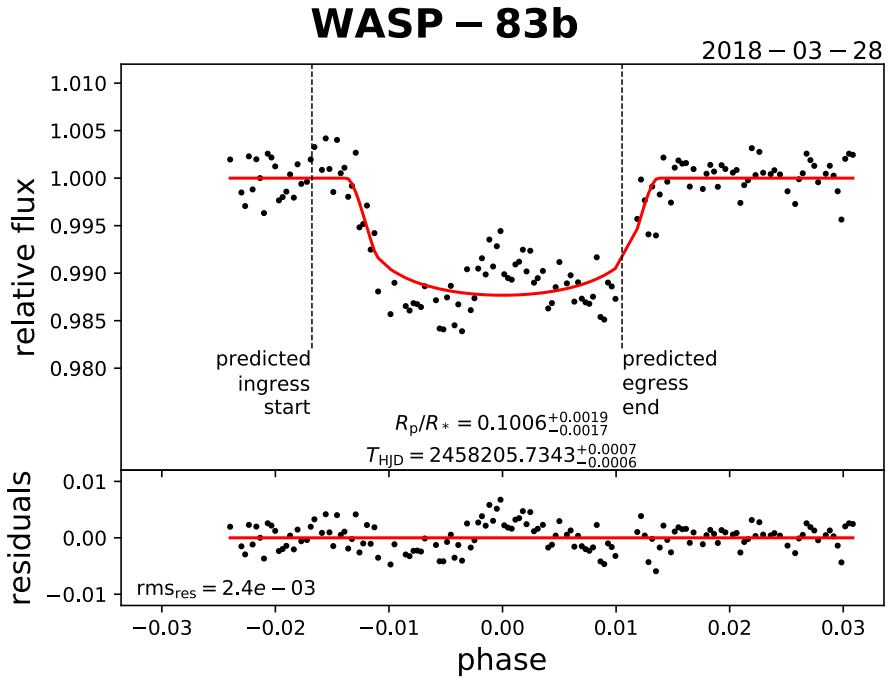
Mandel et al. 2017

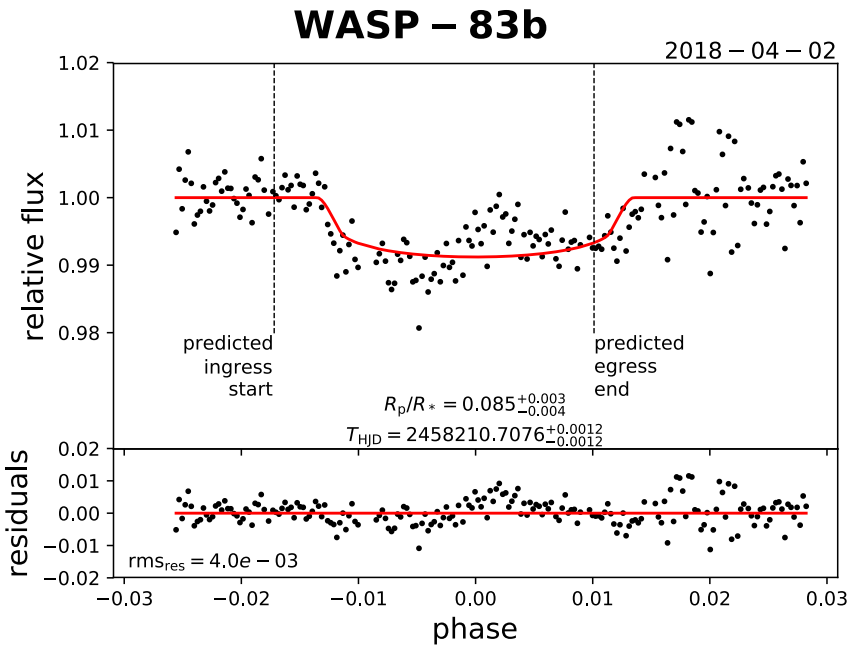
Ephemeris refinement: WASP-83 b

Hellier et al. 2015:
T_0 = 2455928.8853 ± 0.0004
P=4.971252 ± 0.000015
Last observation Feb. 2012

Our observations:
28 / 03 / 2018
02 / 04 / 2018
Expected uncertainty: **± 9 minutes**

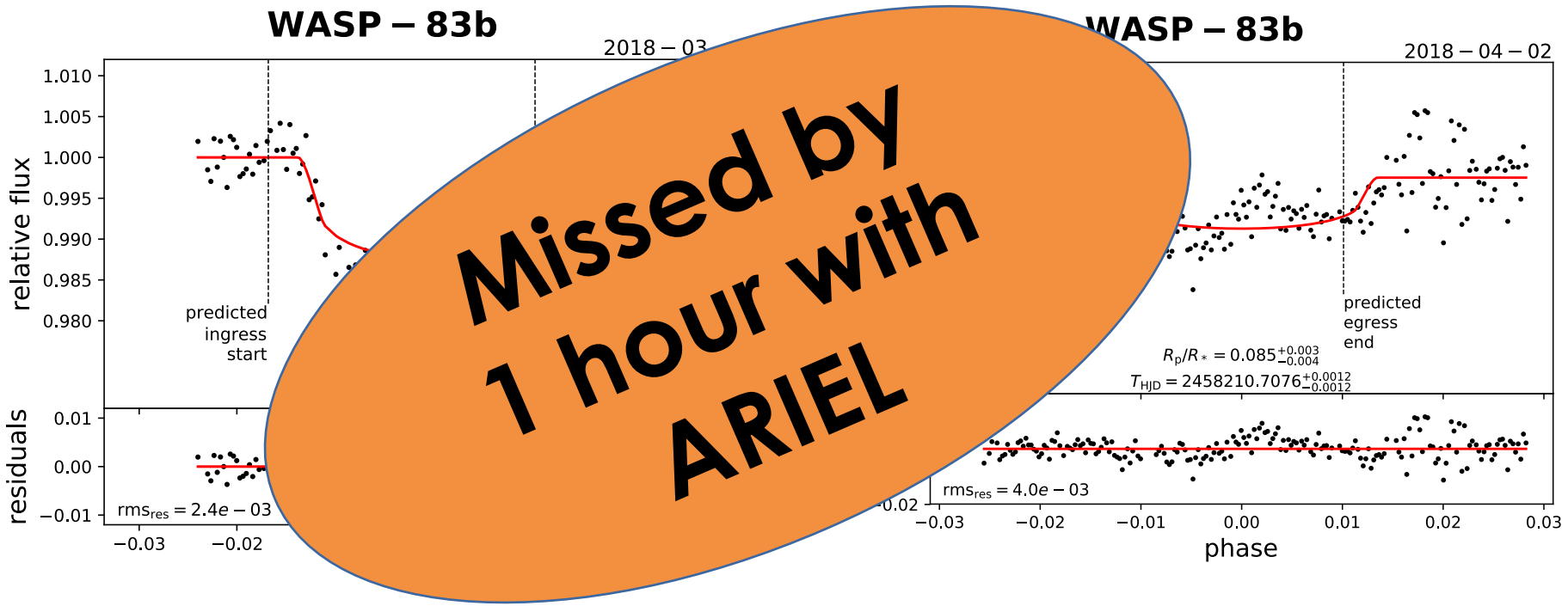
Ephemeris refinement: WASP-83 b





Confirmed time shift of **25 minutes**

Ephemeris refinement: WASP-83 b



Missed by 1 hour with ARIEL

Confirmed time shift of **25 minutes**

The **ExoClock** project

Need for ephemeris confirmation for ~1000 ARIEL targets:

- Not so many observations required: ~1 per 1-2 year(s)!
- But needs to be well organised
- Every transit is a unique opportunity to contribute to the mission
- Observations can be available for further research

What is new in ExoClock

- Open to everyone
- Live up-to-date ephemerides
- Target prioritization with alert system
- Personalised observation schedule
- Direct publications for participants
- Continuous feedback to the observers

Welcome Anastasia!

Logout

Welcome to the ExoClock Project

ExoClock is a project to monitor transiting exoplanets in order to keep their ephemerides up-to-date. Everyone with some basic equipment, including a telescope and a CCD camera, can participate in the effort of monitoring the planets' host stars. If you haven't heard of exoplanet monitoring before, have a look here:
https://exoworldsspies.com/science

Step 1: Register your telescopes

Now that you are ready, go to My Telescopes to register your telescopes. These information is mandatory for us to suggest you which planets to observe, and when. You can always update your telescopes under My Telescopes and your personal info under My Profile

Step 2: Check your schedule

After completing this step, go to My Schedule to see which planets you can observe.

Step 3: Observe a transit

If you don't have any experience on observing transiting exoplanets, all the guidelines on how to record an exoplanet transit are outlined here:
https://exoworldsspies.com/observing

Welcome Anastasia!

Logout

My Telescopes

Name	Size [inches]	Observatory	Latitude [degrees]	Longitude [degrees]	Camera	
C11	11.0	Holomon Astronomical Station	43.4	23.5	ATIK 4000	Delete
c8	8.0	Holomon Astronomical Station	40.4	23.5	ATIK 11000	Delete

Add new Telescope:

Telescope model*

Required.

Telescope Aperture in inches (above 6)*

Planet Name & Remarks	Star RA/DEC [h/deg]	Star Vmag [mag]	Transit Depth [mmag]	Transit Duration [h]	Observ. Start [TZ:2.0]	Transit Start [TZ:2.0]	Transit Mid-point [TZ:2.0]	Transit End [TZ:2.0]	Observ. End [TZ:2.0]
WASP-52b LOW PRIORITY NO PRE-TRANSIT	23:13:58.74 8:45:40.5 FOV	12.0	33.51	1.82	2019/09/06 19:31 16° E	2019/09/06 20:31 27° E	2019/09/06 21:26 36° SE	2019/09/06 22:20 44° SE	2019/09/06 23:20 52° SE
TrES-2b MEDIUM PRIORITY	19:07:14.03 49:18:59.0 FOV	11.41	15.44	1.84	2019/09/06 19:59 82° NE	2019/09/06 20:59 82° NW	2019/09/06 21:54 74° NW	2019/09/06 22:49 66° NW	2019/09/06 23:49 56° NW
HAT-P-32b MEDIUM PRIORITY NO PRE-TRANSIT	2:04:10.28 46:41:16.2 FOV	11.29	29.63	3.12	2019/09/06 20:04 19° NE	2019/09/06 21:04 27° NE	2019/09/06 22:38 41° NE	2019/09/07 00:12 56° NE	2019/09/07 01:12 66° E
Qatar-1b LOW PRIORITY	20:13:31.60 65:09:43.3 FOV	12.84	25.33	1.65	2019/09/06 20:25 66° N	2019/09/06 21:25 68° N	2019/09/06 22:15 68° N	2019/09/06 23:04 65° N	2019/09/07 00:04 60° NW

Upload Observations

Telescope*

- IC Astronomy Observatory - Officina Stellare ProRC 700 - FLI PL16803
- Warrambungle Observatory - Meade LX200ACF - SBIG STXL6303E
- El Sauce Observatory - Planewave CDK24 - FLI ProLine PL9000

File*

Choose file No file chosen

This should be a .TXT file containing only two columns: one for the time and one for the flux. If you are using HOPS you will find a file named "ExoClock_info.txt" in your photomentry folder, with information on what you need to upload.

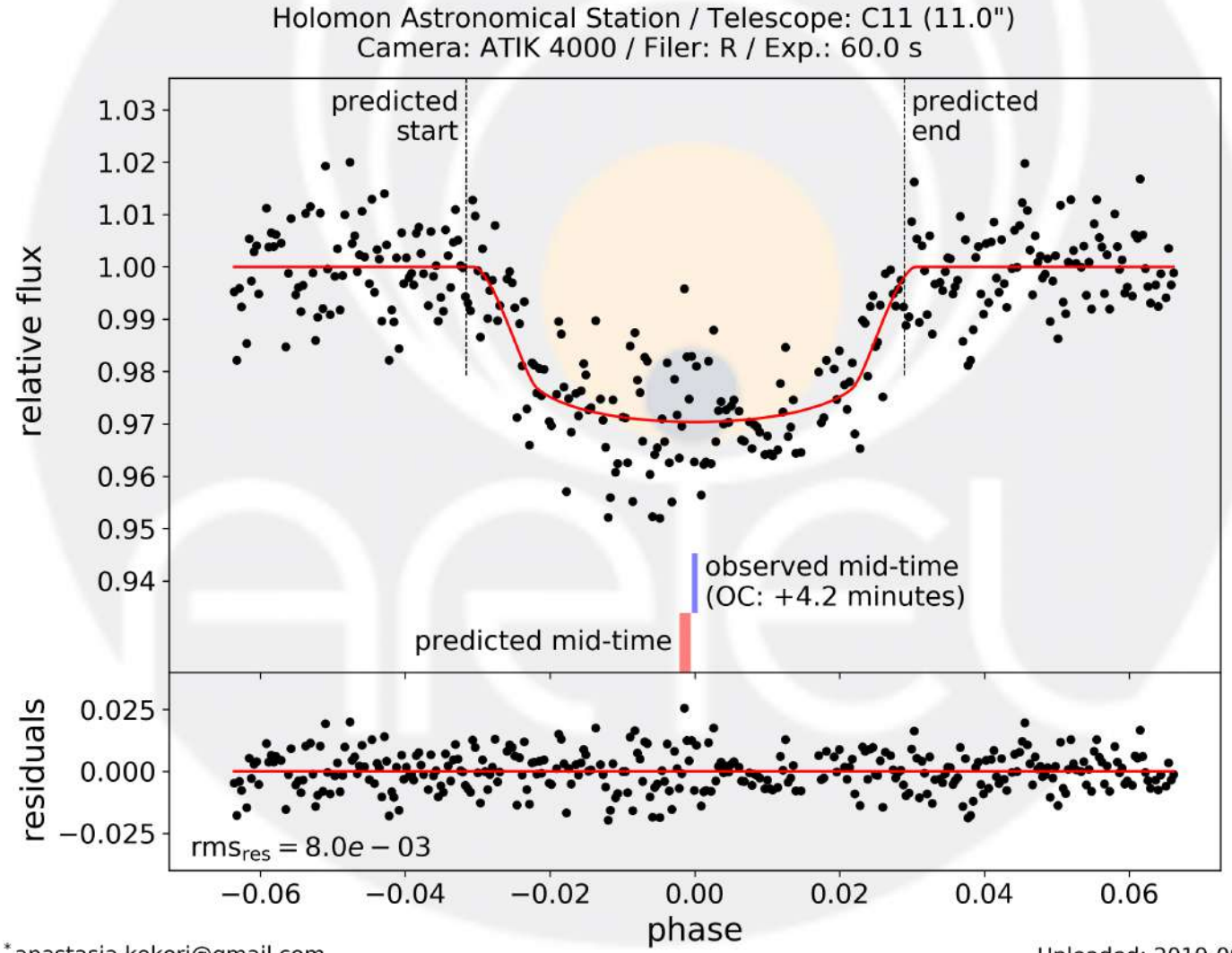
Planet*

55Cnce

HAT − P − 32b

2017-10-05

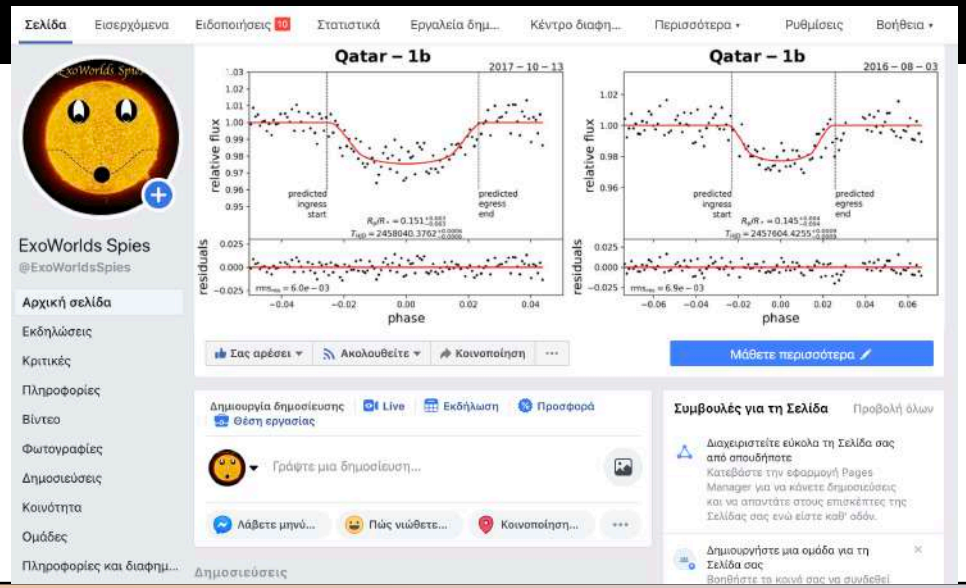
Anastasia Kokori* (UCL, ROG), Angelos Tsiaras (UCL, AUTh)



*anastasia.kokori@gmail.com

Uploaded: 2019-09-06

The Exoworlds Spies project

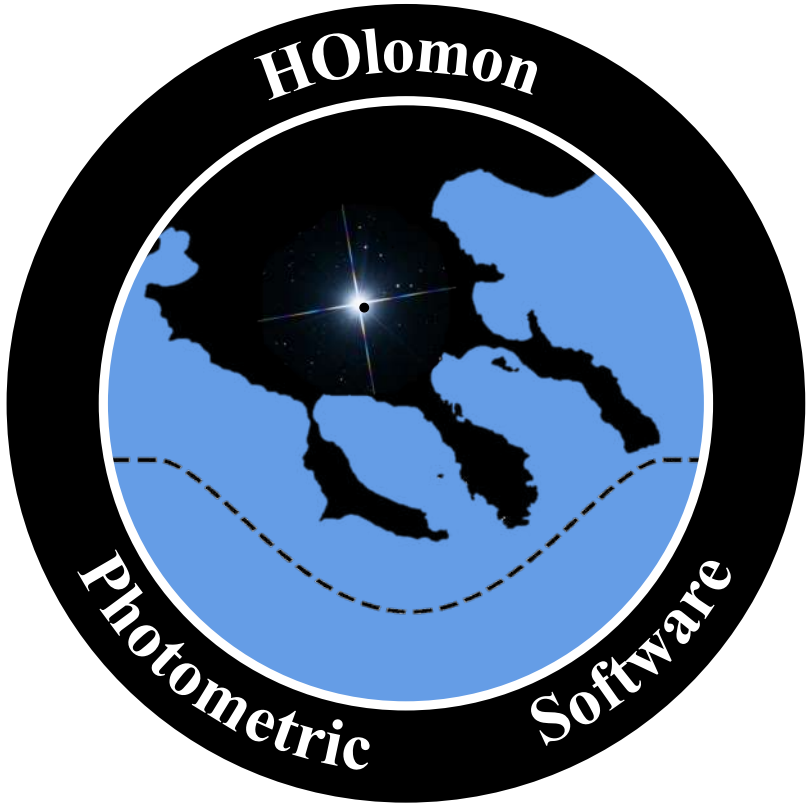


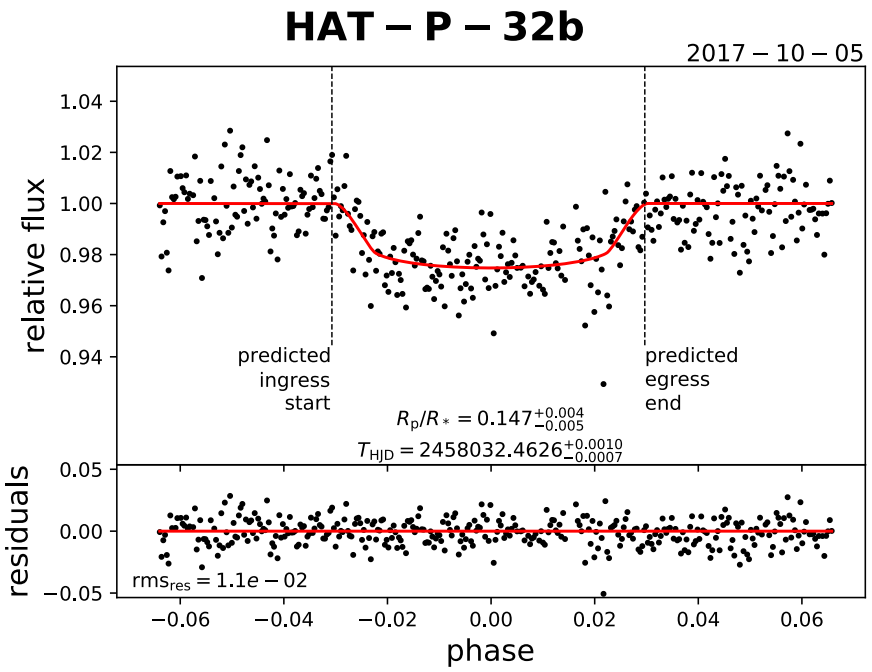
Our strategy

- Education and Research
- Observation toolkit
- Data analysis software
- Educational material (videos, data for training etc)
- Website/ email
- www.exoworldsspies.com

HOPS – the **HO**lomon **P**hotometric **S**oftware

github.com/ExoWorldsSpies/hops





HOPS – characteristics

Open source code

open to contribution from the pro/am communities

GUI for Linux / Mac OS / Windows

no scientific or coding background needed

Written in Python

easy to implement modern scientific codes

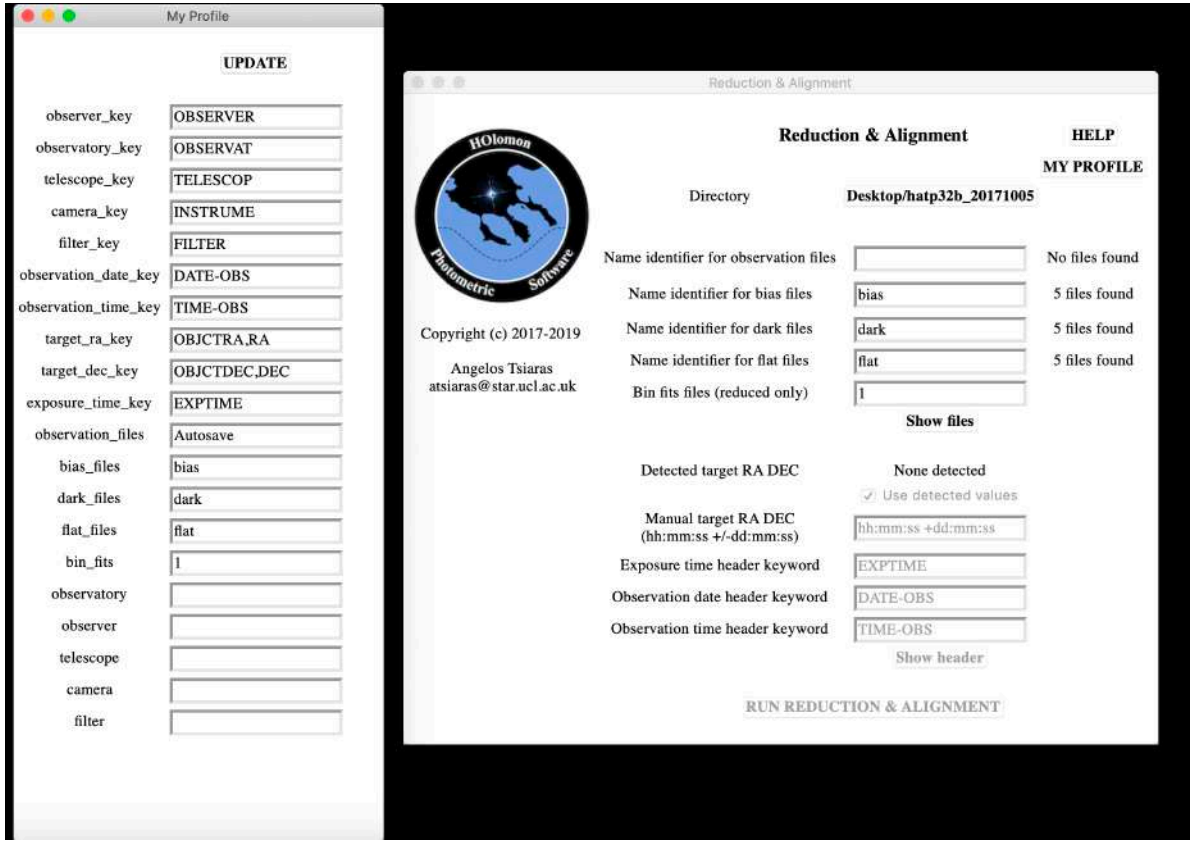
Flexible on data formats

suitable for most small and medium class telescopes

github.com/ExoWorldsSpies/hops

HOPS – features

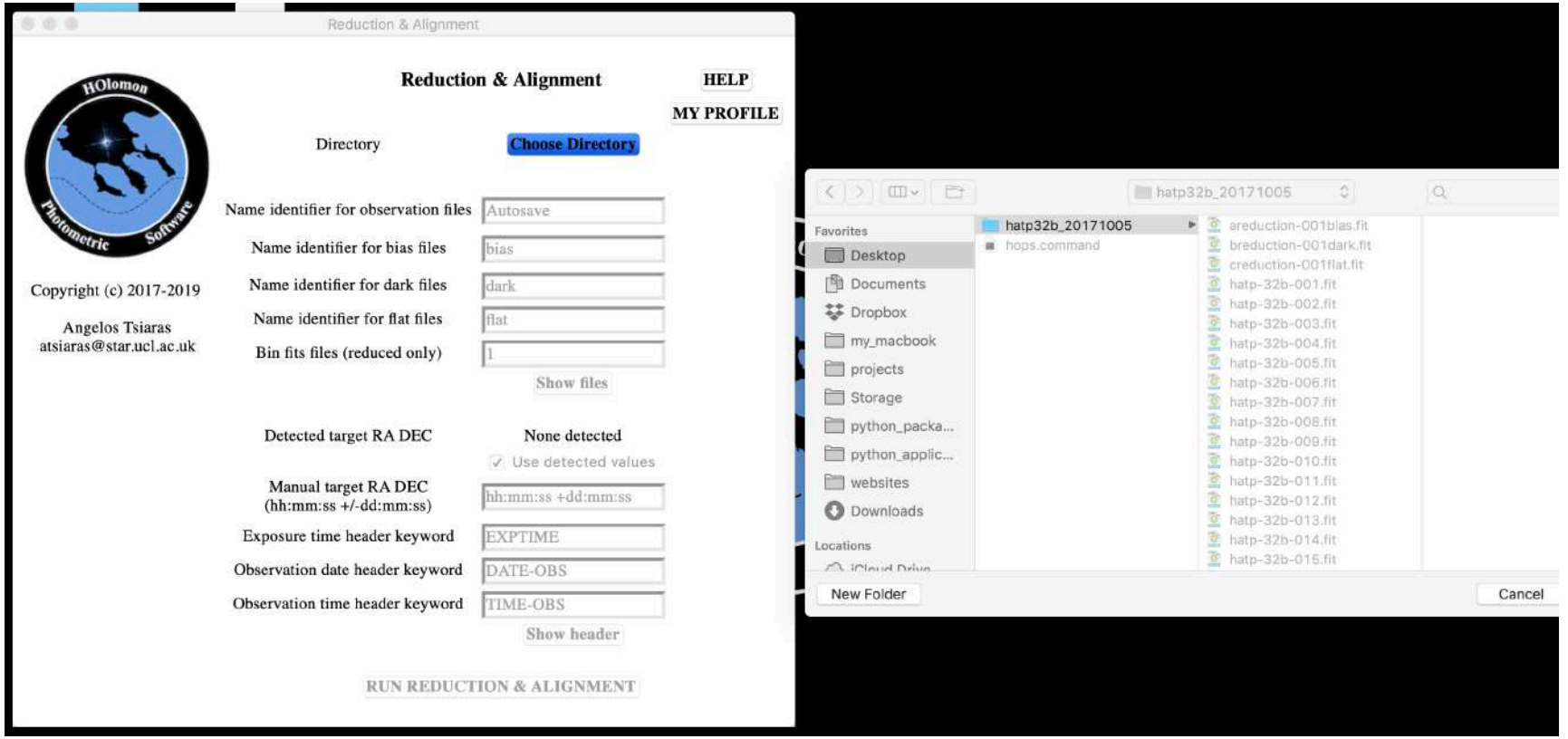
User profile



github.com/ExoWorldsSpies/hops

HOPS – features

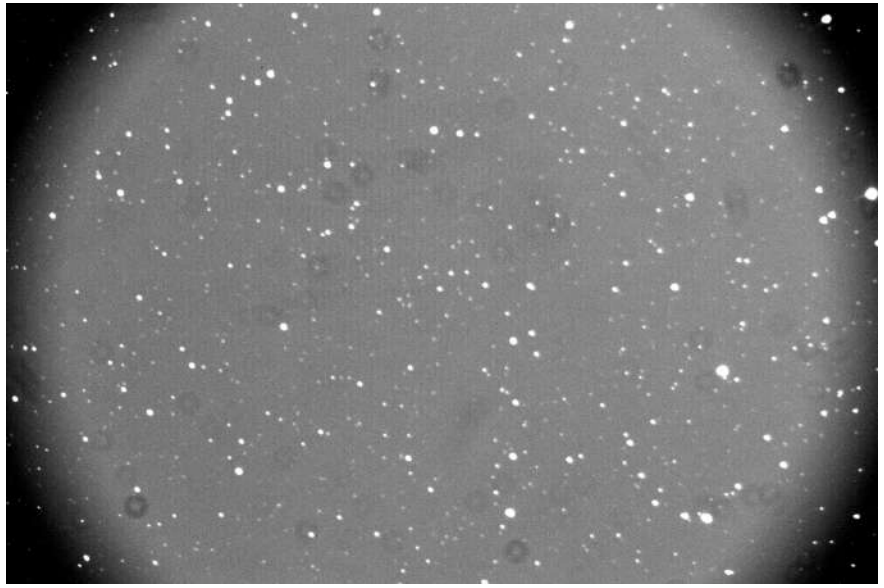
Reduction



github.com/ExoWorldsSpies/hops

HOPS – features

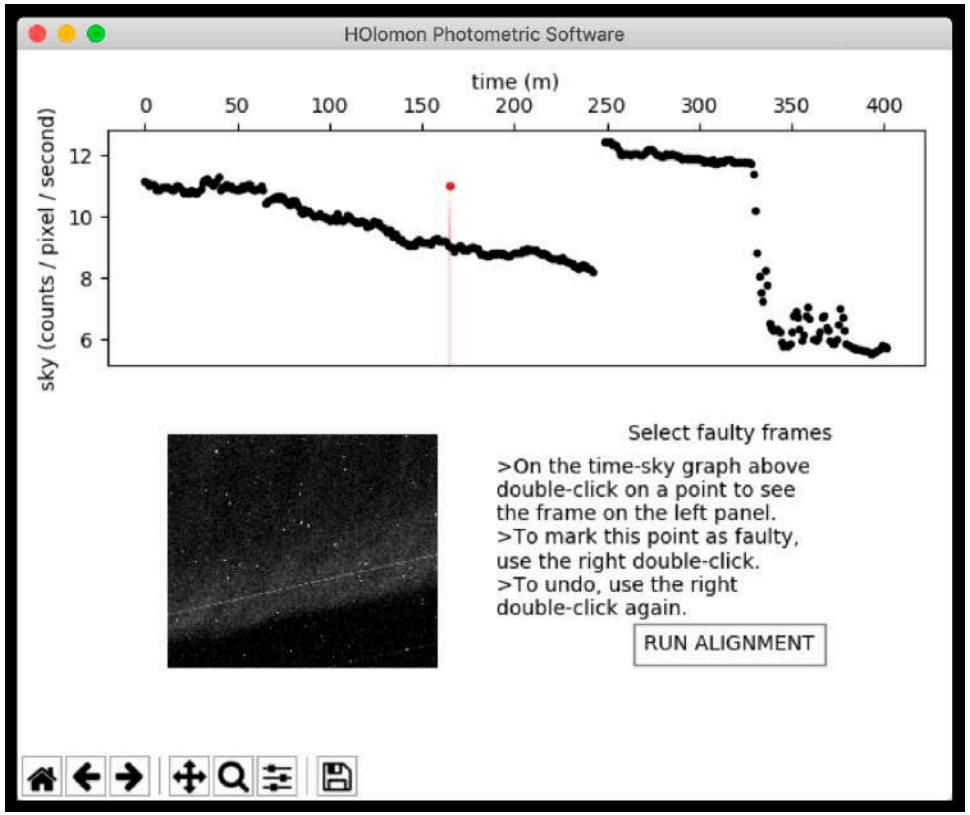
Reduction



github.com/ExoWorldsSpies/hops

HOPS – features

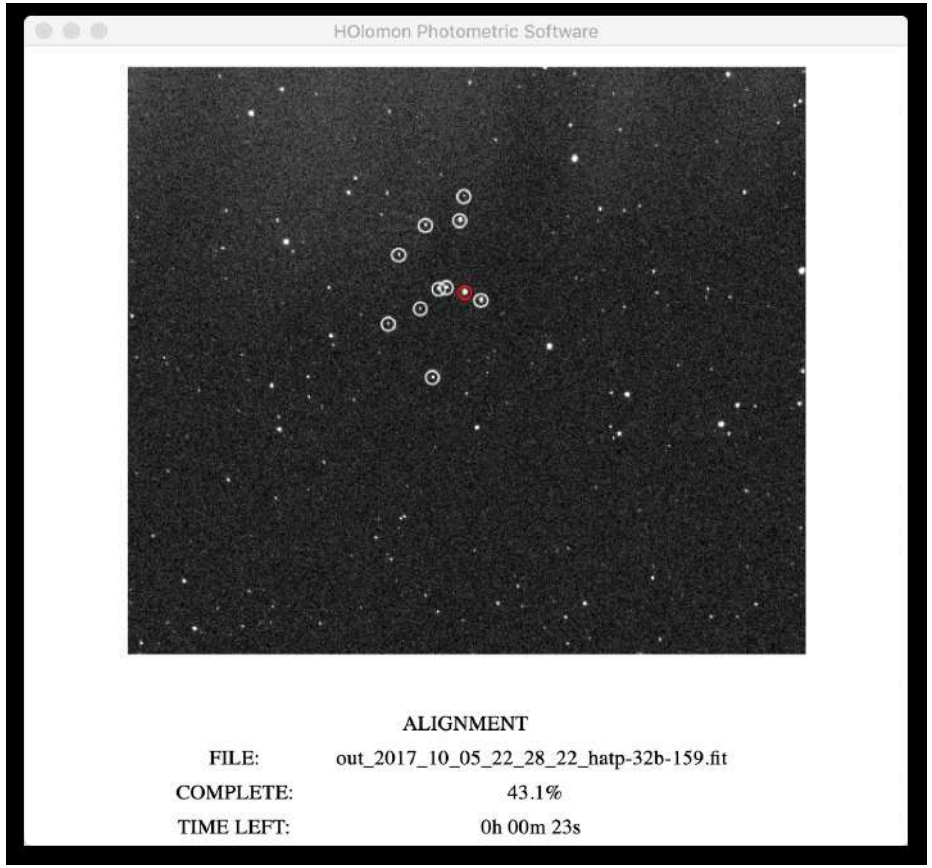
Frame selection

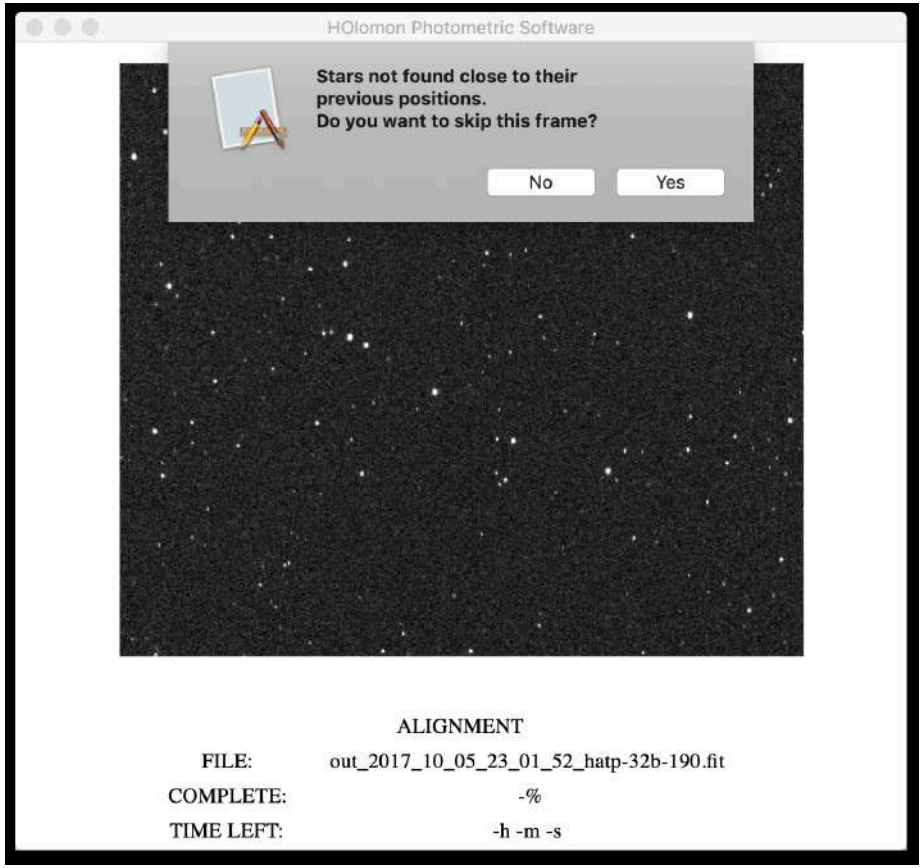


github.com/ExoWorldsSpies/hops

HOPS – features

Alignment

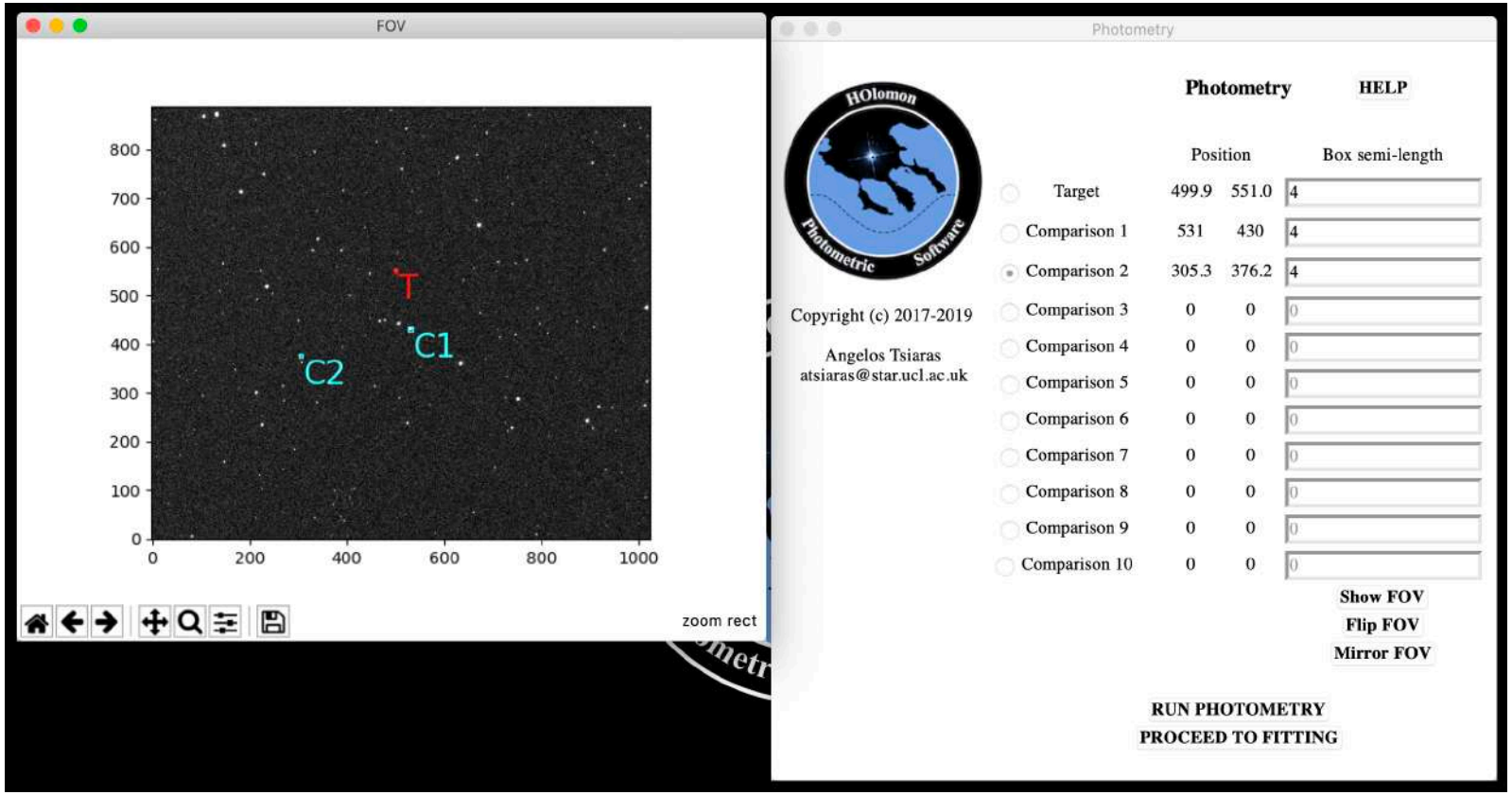




github.com/ExoWorldsSpies/hops

HOPS – features

Photometry



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HOPS – features

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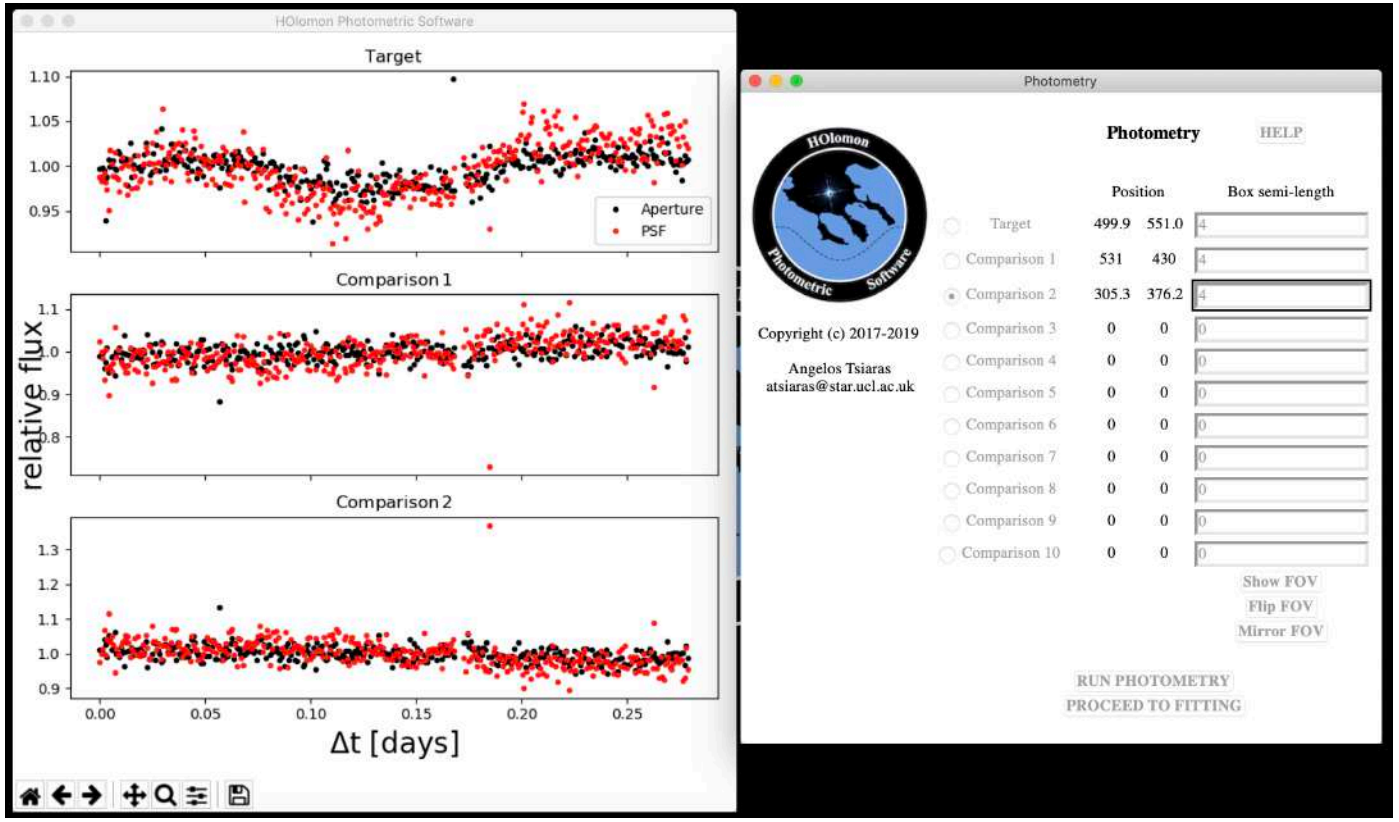


github.com/ExoWorldsSpies/hops

HOPS – features

Photometry – ExoClock_info.txt

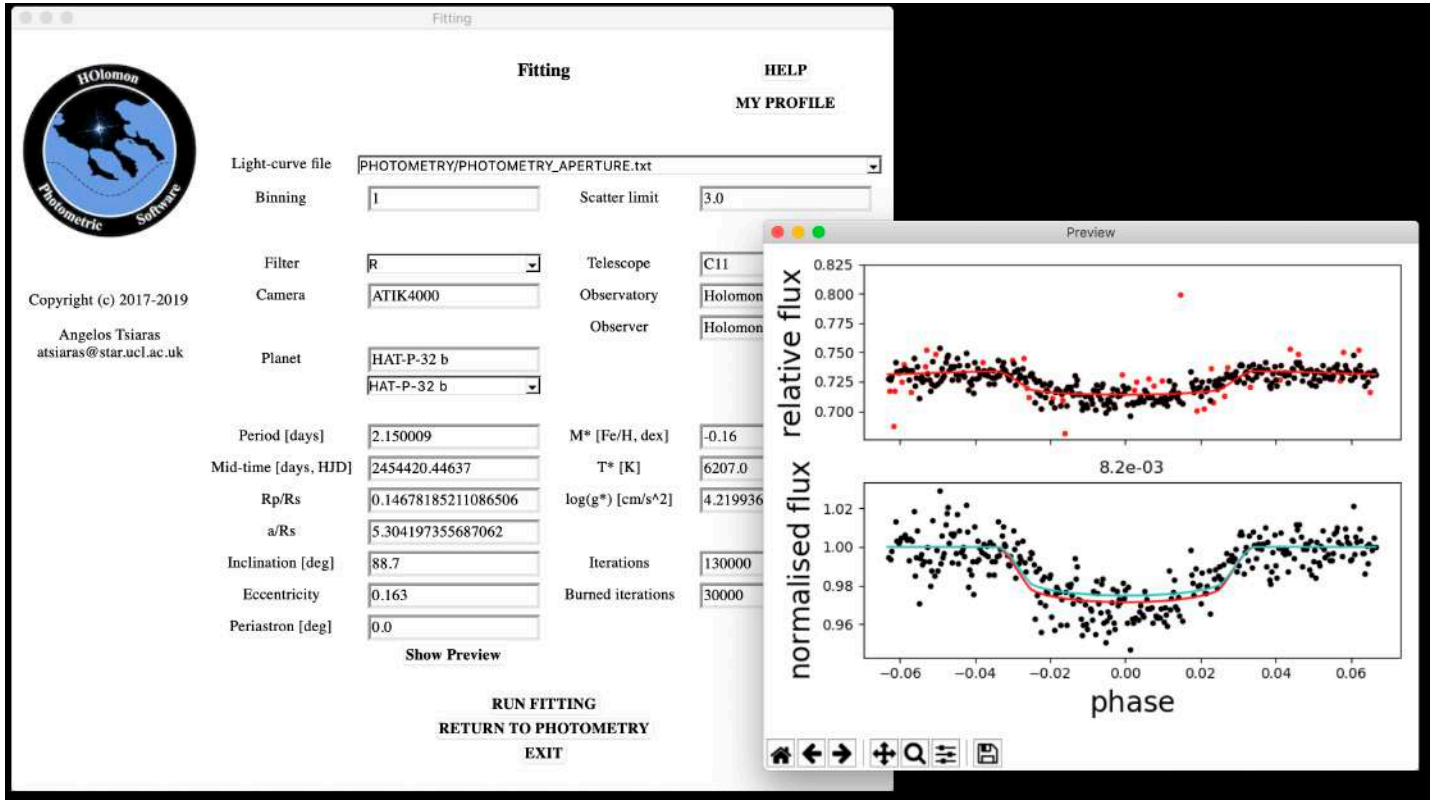
```
The ExoClock Project is an effort to keep the ephemerides of exoplanets as precise as
possible for planning future observations. If you have observed an exoplnaet you can
contribute your observation at:

https://ariel-gbfu.azurewebsites.net

File to upload: PHOTOMETRY_APERTURE.txt
(this is a suggestion based on the scatter
of your light curves, you can also try
uploading PHOTOMETRY_GAUSS.txt)

Planet: HAT-P-32b
(this is the closest known exoplanet found
in the catalogue, if this is not the target
you observed, please ignore)

Time  format: JD_UTC
(UTC-based Julian date)

Flux format: Flux
(flux of target over summed flux of comparisons)

Filter: R

Exposure time in seconds: 60.0
```

HOlomon Photometric Software

github.com/ExoWorldsSpies/hops

HOPS – features

Fitting



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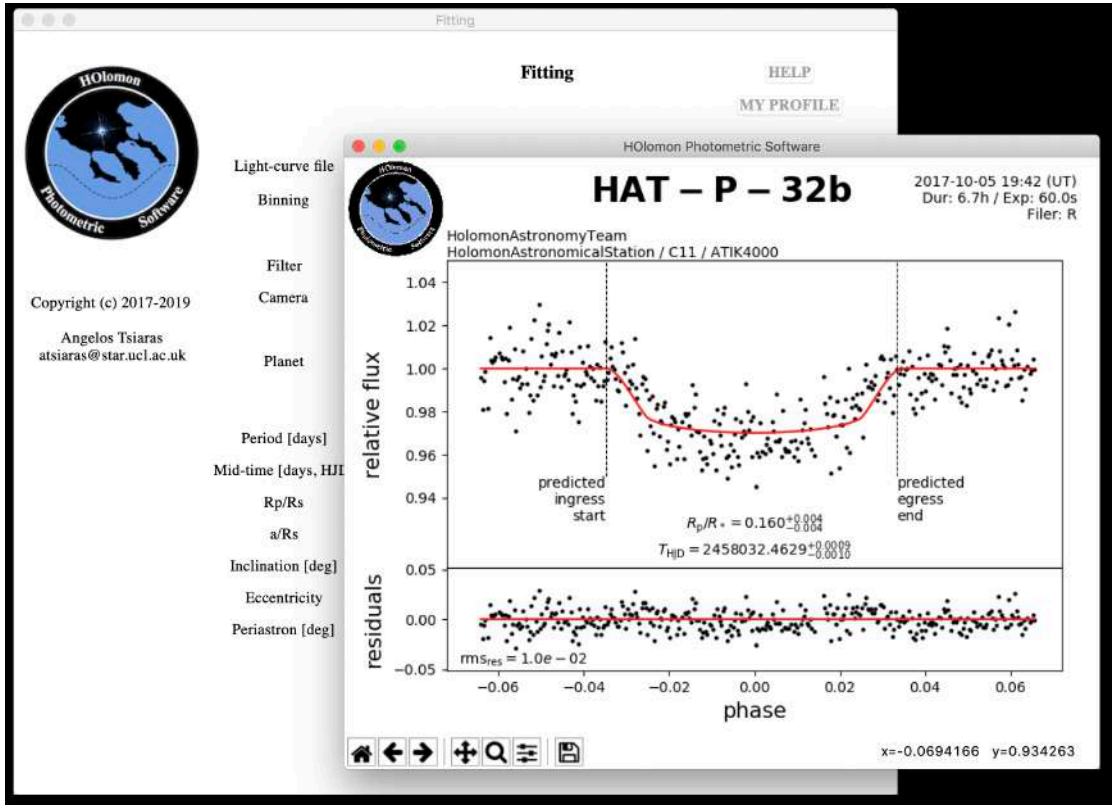

github.com/ExoWorldsSpies/hops

Join us in the ExoClock project!

Register at ExoClock:
exoclock.space

Launched!

Start training at ExoworldsSpies:
www.exoworldsspies.com