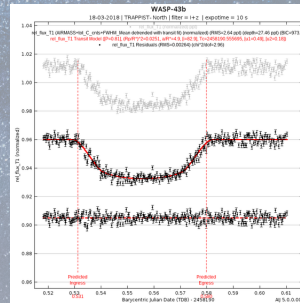
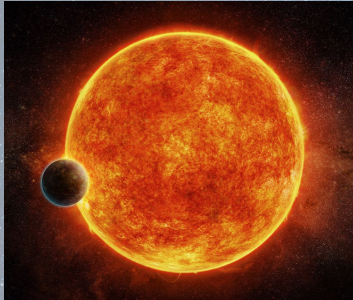


ASTROIMAGEJ

dedicated software to analyze
astronomical observations



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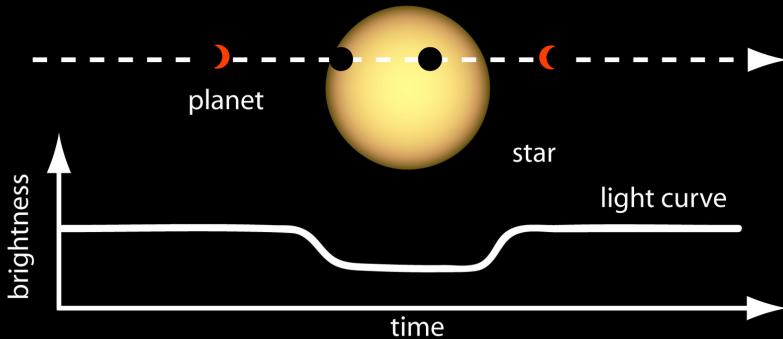
2021-2022

ASTROIMAGEJ

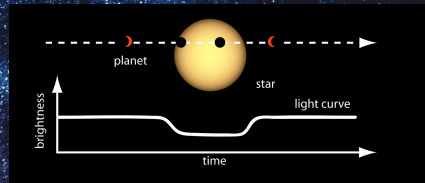
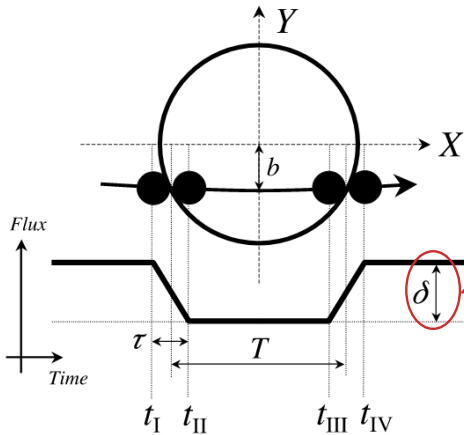
Download, Install (V5) and Read:

<https://www.astro.louisville.edu/software/astroimagej/>

TRANSIT

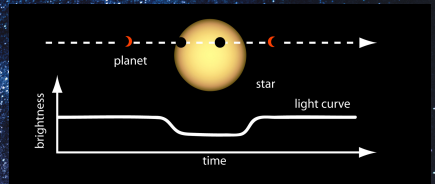
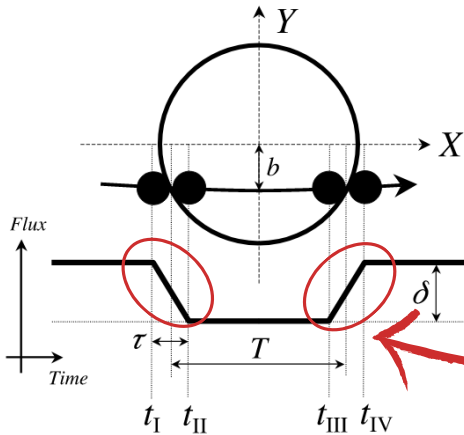


TRANSIT



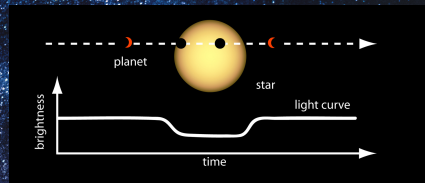
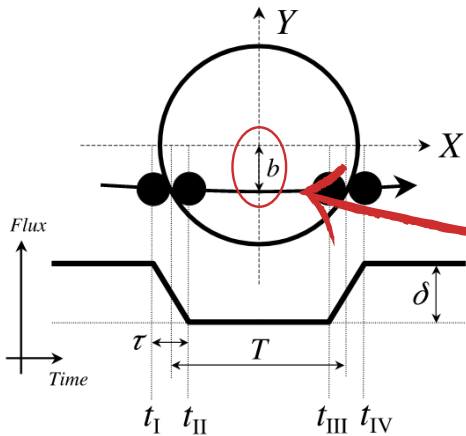
$$\text{Depth} = \left(\frac{R_p}{R_\star} \right)^2$$

TRANSIT



Ingress
Egress

TRANSIT



Impact
parameter

|AstroImageJ

- 1) What is the AIJ package?
- 2) What can we do with AIJ?
 - Data Reduction & Calibration
 - Differential photometry
 - Fitting model (exoplanets)
- 3) Practise yourself with WASP-12b !

|AstroImageJ

1) What is the AIJ package?

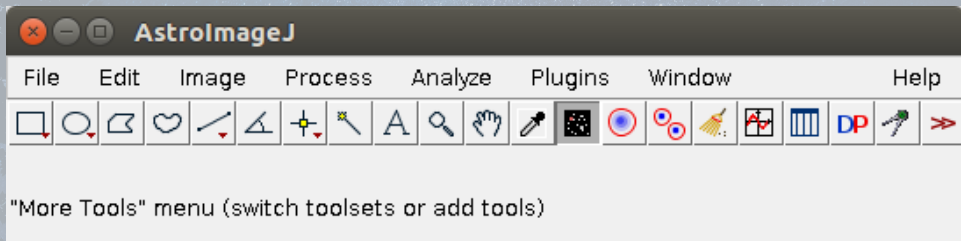
- Graphical User Interface (GUI) software
- Multi-platform (Windows, Mac, Linux) and is Java-based
- Performs time-series differential photometry: exoplanets, asteroids, var. stars
- Do you want more details? Have a look on:

<https://www.astro.louisville.edu/software/astroimagej/>

- This is your first contact with AIJ and is expected you practice more, and read the reference texts, papers, user guide, etc.

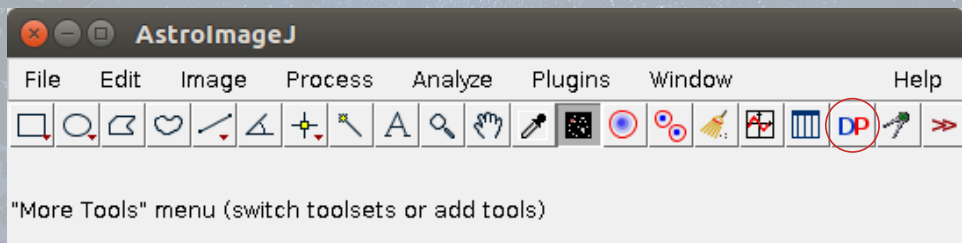
AstroImageJ

2) What can we do with AIJ?



AstroImageJ

2.1) Data Reduction & Calibration



AstroImageJ

2.1) Data Reduction & Calibration

The screenshot shows the CCD Data Processor interface with the following sections and data:

- Science Image Processing:** A table with columns for Control, Options, Directory, Filename/Pattern, and Totals. It lists Science Image Processing with 339 files.
- Bias Subtraction:** A table with columns for Control, Options, Directory, Filename/Pattern, and Totals. It lists Bias Subtraction with 9 files.
- Dark Subtraction:** A table with columns for Control, Options, Directory, Filename/Pattern, and Totals. It lists Dark Subtraction with 54 files.
- Flat Division:** A table with columns for Control, Options, Directory, Filename/Pattern, and Totals. It lists Flat Division with 7 files.
- Image Correction:** A section with checkboxes for Enable Linearity Correction, Remove Outliers, Bright, Dark, and Radius, and a Threshold field.
- FITS Header Updates:** A section with checkboxes for General and Plate Solve, and fields for Target Coordinate Source and Observatory Location Source.
- Save Calibrated Images:** A section with checkboxes for Enable, Save Image, and Save Plot, and fields for Sub-dir, Suffix, and Format.
- Post Processing:** A section with checkboxes for M-App, M-Plot, and Save Image, and fields for Macro 1 and Macro 2.
- Control Panel:** A section with a Polling Interval field and buttons for Set, Start, Pause, and Reset.

Section	Control	Options	Directory	Filename/Pattern	Totals
Science Image Processing	<input checked="" type="checkbox"/>	Match	/home/pozuelos/Dropbox/teaching/curso_2020/exoplanets_uliege/datos/WASP-43b-12032018/	WASP*	339
Bias Subtraction	<input checked="" type="checkbox"/>	ave	/home/pozuelos/Dropbox/teaching/curso_2020/exoplanets_uliege/datos/WASP-43b-12032018/Calibration/	Bias*	9
Dark Subtraction	<input checked="" type="checkbox"/>	scale	/home/pozuelos/Dropbox/teaching/curso_2020/exoplanets_uliege/datos/WASP-43b-12032018/Calibration/	Dark*	54
Flat Division	<input checked="" type="checkbox"/>	ave	/home/pozuelos/Dropbox/teaching/curso_2020/exoplanets_uliege/datos/WASP-43b-12032018/AutoFlat/	Flat*	7

After an observation night you should have:

- Science Images
- Calibration Images (Flats, Darks and Bias)

Pag. 17 to 21

Mathilde's presentation

AstroImageJ

2.1) Data Reduction & Calibration

Pag. 17

Mathilde's presentation

CCD Data Processor

File Preferences View

Control Options Directory Filename/Pattern Totals

Science Image Processing

Filename Pattern Matching

Enable Sort Num WASP* 339

Filename Number Filtering

Enable Min Max WASP* 339

Bias Subtraction

Build ave med Bias* 9

Enable mbias.fits 0

Dark Subtraction

Build ave med Dark* 54

Enable scale daskias mark.fits 0

Flat Division

Build ave med Au* 7

Enable Remove Gradient mflat.fits 0

Image Correction

Enable Linearity Correction New pixel value = + × (PixVal) + × ((PixVal)² + × (PixVal)³

Remove Outliers Bright Dark Radius Threshold

FITS Header Updates

General Plate Solve Target Coordinate Source Observatory Location Source

FITS header target RA/DEC (J2000) FITS header latitude and longitude

Save Calibrated Images

Enable 16 32 Sub-dir: pipelineout Suffix: _out Format: GZIP

Post Processing

M-App Save Image Macro 1 0

M-Plot Save Plot Macro 2 0

Control Panel

Polling Interval

Processed: 0
Remaining: 339

General FITS Header Settings

FITS Header Input Settings

Target Name Keyword: OBJECT

Target RA Keyword: OBJCTRA Degr...

Target DEC Keyword: OBJCTDEC

Observatory Name Keyword: TELESCOP

Observatory Latitude Keyword: SITELAT negate

Observatory Longitude Keyword: SITELONG negate

FITS Header Output Settings

Target J2000 RA Keyword: RAOBJ2K enable

Target J2000 DEC Keyword: DEC OBJ2K enable

Target RA Keyword: RA OBJ enable

Target DEC Keyword: DEC OBJ enable

Target Altitude Keyword: ALT OBJ enable

Target Azimuth Keyword: AZ OBJ enable

Target Hour Angle Keyword: HA OBJ enable

Target Zenith Distance Keyword: ZD OBJ enable

Target Airmass Keyword: AIRMASS enable

JD (UTC) start-Obs Keyword: JD SOBS enable

JD (UTC) mid-Obs Keyword: JD UTC enable

HJD (UTC) mid-Obs Keyword: HJD UTC enable

BJD (TDB) mid-Obs Keyword: BJD TDB enable

Observatory Latitude Keyword: SITELAT enable

Observatory Longitude Keyword: SITELONG enable

AstroImageJ

2.1) Data Reduction & Calibration

CCD Data Processor

File Preferences View

Control Options Directory

Science Image Processing

Filename Pattern Matching

Enable Sort Num

Filename Number Filtering

Enable

Bias Subtraction

Build ave med

Enable

Dark Subtraction

Build ave med

Enable scale dslr

Flat Division

Build ave med

Enable Remove Gradient

Image Correction

Enable Linearity Correction

Remove Outliers Bright Dark

FITS Header Updates

General Plate Solve

Save Calibrated Images

Enable 16 32

Post Processing

M-App Save Image M-Plot Save Plot

Control Panel

START

Processed: 0
Remaining: 339

AstroImageJ

2.1) Data Reduction & Calibration

The screenshot displays the 'CCD Data Processor' application window. The interface is divided into several sections:

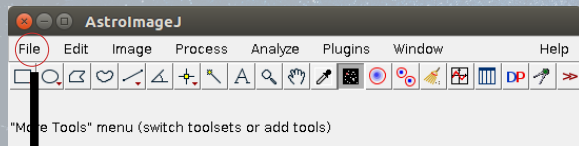
- Control Panel:** Located at the bottom, it includes a 'Polling Interval' set to 0, and buttons for 'Set', 'START' (circled in red), 'PAUSE', and 'RESET'. It also shows 'Processed: 0' and 'Remaining: 339'.
- Science Image Processing:** Includes 'Filename Pattern Matching' with 'Enable' checked and 'Sort Num' set to 1. 'Filename Number Filtering' is also checked.
- Bias Subtraction:** 'Build' is checked, 'med' is selected. The directory path is '/home/pozuelos/Dropbox/teaching/curso_2020/exoplanets_uliege/datos/WASP-43b-12032018/Calibration'.
- Dark Subtraction:** 'Build' is checked, 'scale' is selected. The directory path is the same as for Bias Subtraction.
- Flat Division:** 'Build' is checked, 'ave' is selected. The directory path is '/home/pozuelos/Dropbox/teaching/curso_2020/exoplanets_uliege/datos/WASP-43b-12032018/AutoFlat'.
- Image Correction:** 'Enable Linearity Correction' is checked. The formula for new pixel value is shown as $\text{New pixel value} = \text{0.00} + 1.00 \times (\text{PixVal}) + \text{0.00} \times (\text{PixVal})^2 + \text{0.00} \times (\text{PixVal})^3$. 'Remove Outliers' is checked with 'Bright' selected and 'Radius' set to 5.
- FITS Header Updates:** 'General' is checked. 'Target Coordinate Source' is 'FITS header target RA/DEC (J2000)' and 'Observatory Location Source' is 'FITS header latitude and longitude'.
- Save Calibrated Images:** 'Enable' is checked, '16' bits, '32' sub-dir: 'pipelineout', 'Suffix: '_out', and 'Format: GZIP'.
- Post Processing:** 'M-App' and 'M-Plot' are unchecked. 'Save Image' and 'Save Plot' are checked, both pointing to a directory on the desktop.
- Log Window:** Opened on the right, it shows a list of processed files with timestamps and a detailed log for the first file, including coordinates, β , HJD, BPTOBI, Altitude, Azimuth, Hour Angle, Zenith Distance, Airmass, and correction details.

AstroImageJ

2.2) Differential photometry

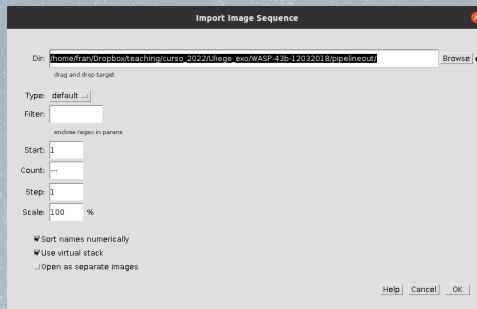
Pag. 22 to 23

Mathilde's presentation



Import

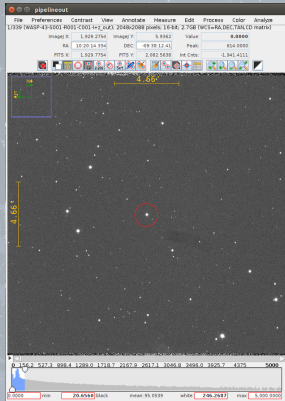
Image Sequence



**Calibrated
Images!**

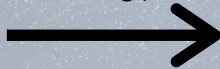
AstroImageJ

2.2) Differential photometry (Aperture selection)



Field of View

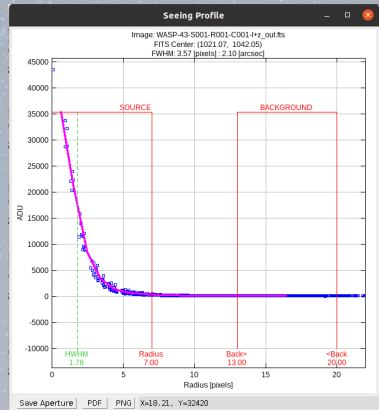
- (1) Click on T1
- (2) Analyse tab
- (3) Seeing profile



Optimum aperture

Pag. 22

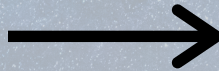
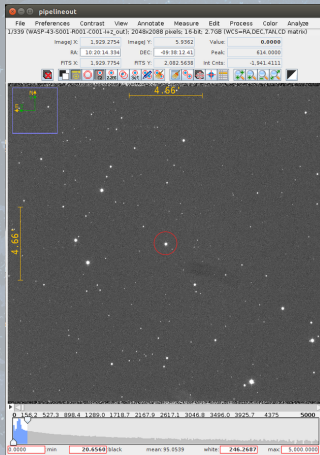
Mathilde's presentation



Seeing profile

AstroImageJ

2.2) Differential photometry (Aperture selection)

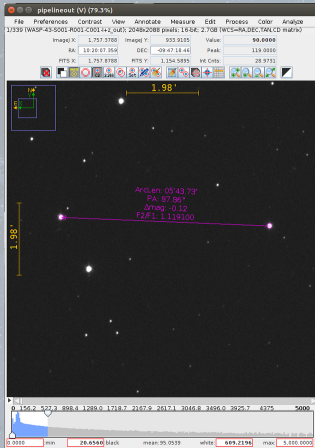


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Mathilde's presentation



AstroImageJ

2.2) Differential photometry (comparison stars)



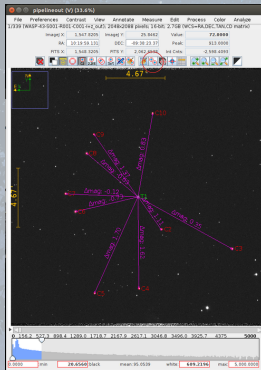
- Similar brightness (Delta Mag < |1.5|)
- As flat as possible (to be checked later)

Hold click right and drop over a comparison star

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Mathilde's presentation

AstroImageJ

2.2) Differential photometry (comparison stars)



Multi-Aperture Measurements

First slice: 1
Last slice: 239

Auto Radius
Radius of object aperture: 7
Inner radius of background annulus: 13
Outer radius of background annulus: 20

Use previous N apertures (N=click to set first aperture localized)
 Use RADes to locate aperture positions
 Use single step mode (N=click to set first aperture location in each image)
 Allow aperture changes between slices in single step mode (right click to advance image)

Auto comparison stars Enable log Show pixels
Smoothing Fiber Radius: 1 pixel

Auto Thresholds:	Max. Peak Value:	Min. Peak Value:
None Aperture	10000	10000
	10000	10000

Weight of brightness vs. distance: 1.00
Min. Comp. Brightness %: 100
Max. Comp. Stars: 1

Centroid apertures (initial settings) Half processing on WCS or centroid error
 Remove stars from background Assume background is a plane

Vary aperture radius based on FWHM
Pixel factor (set to 0.00 for radial profile mode): 14
Radial profile mode normalized flux cutoff: 0.99 (0 < cutoff < 1, default = 0.020)

Prompt to enter ref star apparent magnitude (required if target star apparent mag is desired)
 Update table and plot while running Show help panel during aperture selection

CLICK PLACE APERTURES AND SELECT APERTURE LOCATIONS WITH LEFT CLICKS.
THEN RIGHT CLICK or +ENTER to BEGIN PROCESSING.
To abort aperture selection or processing, press +ESC+.

Aperture Settings Cancel **Place Apertures**

Multi-Aperture Help

- left-click: Add target star aperture T1
- <Shift>-left-click: Add reference star aperture C1
- <Shift>-<Ctrl>-left-click: Zoom In
- <Alt>-left-click: Zoom Out
- <Alt>-left-click: Invert sense of centroid setting for new aperture
- right-click:
 - <Enter>: Measure arc length
 - <Ctrl>-left-click: Zoom In
 - <Ctrl>-right-click: Zoom Out
 - roll mouse wheel: Zoom In/Out
 - left-click-drag: Pan image up/down/left/right
 - middle-click: Center clicked point in image display (if enabled in Preferences menu)
 - <escape>: Cancel Multi-Aperture

↓
Press Enter

AstroImageJ

2.2) Differential photometry (plotting results)



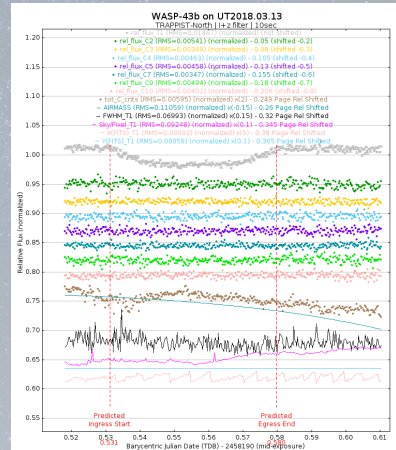
AstroImageJ

2.2) Differential photometry (plotting results)

Obs. ID	Time	Filter	Exposure	Flux	Flux Error	Flux Ratio	Flux Ratio Error	Flux Ratio Error	Flux Ratio Error	Flux Ratio Error
1	00:00:00	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	00:00:05	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	00:00:10	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	00:00:15	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	00:00:20	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	00:00:25	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	00:00:30	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	00:00:35	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	00:00:40	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	00:00:45	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	00:00:50	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	00:00:55	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	00:01:00	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	00:01:05	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	00:01:10	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	00:01:15	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	00:01:20	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	00:01:25	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	00:01:30	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	00:01:35	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21	00:01:40	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	00:01:45	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	00:01:50	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24	00:01:55	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
25	00:02:00	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
26	00:02:05	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27	00:02:10	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28	00:02:15	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
29	00:02:20	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	00:02:25	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
31	00:02:30	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
32	00:02:35	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
33	00:02:40	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
34	00:02:45	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
35	00:02:50	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
36	00:02:55	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
37	00:03:00	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
38	00:03:05	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	00:03:10	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	00:03:15	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
41	00:03:20	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
42	00:03:25	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
43	00:03:30	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
44	00:03:35	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
45	00:03:40	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
46	00:03:45	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
47	00:03:50	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48	00:03:55	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
49	00:04:00	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	00:04:05	Dark gray	0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Plot:

- T1 flux
- expected ingress and egress times
- Comparison stars fluxes
- Typical systematics (airmass, sky/pixel, FWHM, X-Y, BJD_TDB, total_C_cnts)



AstroImageJ

2.3) Fitting model

Multi-plot Y-data

Data Set	New Cal	Plot	Auto Scale	X-data	Input in Mag	Y-data	Auto Error	Function	Y-operand	Color	Symbol	Lines	Bin Size	Smooth	Length	Fit Mode	Trend Select	Trend Coefficient	Trend Dataset	Normy Mag Ref	Out Mag	Page Ref	Scale	then Shift	Legend Type	Custom
1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_T1	<input checked="" type="checkbox"/>	none		light gr...	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0001764 0.00000000		<input checked="" type="checkbox"/>		10	10	0	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	(not fitted)
2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_T1	<input checked="" type="checkbox"/>	none		dark gr...	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000	AIRMASS	<input checked="" type="checkbox"/>		10	10	-0.04	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.1
3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C2	<input type="checkbox"/>	none		dark gr...	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.05	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.2
4	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C3	<input type="checkbox"/>	none		orange	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.08	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.3
5	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C4	<input type="checkbox"/>	none		light blue	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.105	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.4
6	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C5	<input type="checkbox"/>	none		purple	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.12	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.5
7	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C7	<input type="checkbox"/>	none		teal	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.155	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.6
8	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C9	<input type="checkbox"/>	none		green	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.18	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.7
9	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C10	<input type="checkbox"/>	none		pink	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.206	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.8
10	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C10	<input type="checkbox"/>	none		dark gr...	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.075	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -0.9
11	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C9	<input type="checkbox"/>	none		blue	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.085	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -1.0
12	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_Rain_C10	<input type="checkbox"/>	none		red	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.095	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -1.1
13	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	HE_C_08a	<input type="checkbox"/>	none		brown	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	1.0252000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.245	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	Page Ref Shv
14	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	AIRMASS	<input type="checkbox"/>	none		teal	line	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.26	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	Page Ref Shv
15	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	PW98_T1	<input type="checkbox"/>	none		black	line	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0010000 0.00100000		<input checked="" type="checkbox"/>		10	10	-0.32	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	Page Ref Shv
16	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	StopFinal_T1	<input type="checkbox"/>	none		magenta	line	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.345	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	Page Ref Shv
17	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	KP119_T1	<input type="checkbox"/>	none		pink	line	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0001764 0.00017640		<input checked="" type="checkbox"/>		10	10	-0.36	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	Page Ref Shv
18	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>	Y1193_T1	<input type="checkbox"/>	none		light blue	line	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-0.965	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	Page Ref Shv
19	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RJD_TDB	<input type="checkbox"/>		<input type="checkbox"/>	none		orange	dot	<input type="checkbox"/>	10	10	10	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	0.0000000 0.00000000		<input checked="" type="checkbox"/>		10	10	-1.215	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	isfitted -1.2

AstroImage

2.3) Fitting model

Initial Parameters

Parameter	Unit	Value
P	days	0.833333
Teff	K	4000

Transit Parameters

Parameter	Value
b	0.4984

Detrend Parameters

Parameter	Value
u	0.0941082413

Use the available values of:

- Period
- Teff
- Compute the LD (Limb Darkening coefficients)

https://exockt.stsci.edu/limb_darkening

- Temp (K)
 - Metallicity [Fe/H]
 - log(g)
 - Filter
- } ExoFOP

AstroImageJ

2.3) Fitting model

Apply some **detrends** to improve your model

Parameter

Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	StepSize
Baseline Flux (mag)	0.872212028	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
$\sigma_p / \sigma_{\text{fit}}$	0.820702662	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
$\sigma_p / \sigma_{\text{fit}}$	0.820892662	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
$\sigma_p / \sigma_{\text{fit}}$	0.820892662	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
Indication (mag)	0.8305712028	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
Linear US fit	0.489800000	<input type="checkbox"/>	0.489800000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
Quadratic US fit	0.375600000	<input type="checkbox"/>	0.375600000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000

Calculated from model

Depth (mag)	US fit	US fit (mag)	US fit (mag)	US fit (mag)	US fit (mag)	US fit (mag)
27.46	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000

Detrended Parameters

Use	Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	StepSize
<input type="checkbox"/>	airmass	-0.0841102413	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
<input type="checkbox"/>	sky_pix	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
<input type="checkbox"/>	FWHM	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
<input type="checkbox"/>	X	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
<input type="checkbox"/>	Y	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
<input type="checkbox"/>	BJD_TDB	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
<input type="checkbox"/>	total_C_cnts	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000

Fitted Parameters

Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	StepSize
BIC	978.3696	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000

Fitted Parameters

Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	StepSize
airmass	-0.0841102413	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
sky_pix	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
FWHM	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
X	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
Y	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
BJD_TDB	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000
total_C_cnts	0.000000000	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000

Fitted Parameters

Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	StepSize
BIC	978.3696	<input type="checkbox"/>	0.000000000	<input type="checkbox"/>	0.000000000	0.000000000	0.000000000

- airmass
- sky/pixel
- FWHM
- X & Y
- BJD_TDB
- total_C_cnts

The lower the BIC the better
BIC (Bayesian Information Criterion)

AstroImage

2.3) Fitting model

rdc_fit_01

User Specified Parameters (not fitted)

Orbital Parameters

Period (days)	0.810000	Fit	Min	Max	Log	Host Star Parameters (center on)	Star Type	Star Color	Star Mass (M _{sun})	Star Radius (R _{sun})	Star Temp (K)	Star Age (Gyr)
	0.810000	<input checked="" type="checkbox"/>	0.000000	1.000000	<input checked="" type="checkbox"/>	Star Type	Star Color	Star Mass (M _{sun})	Star Radius (R _{sun})	Star Temp (K)	Star Age (Gyr)	Star Age (Gyr)
						K7V	G0V	0.600000	0.700000	0.400000	0.000000	2.375000

Transit Parameters

Enable Transit Fit Auto Update Prior Exclude Prior Center Values From Light Curve, DBS, and FIT Metrics

Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	Weight
Baseline Flux (mag)	0.97222029	<input checked="" type="checkbox"/>	0.97222029	<input checked="" type="checkbox"/>	0.00000000	0.00000000	0.00000000
R_p / R_*	0.02207080	<input checked="" type="checkbox"/>	0.02207080	<input checked="" type="checkbox"/>	0.00000000	0.00000000	0.00000000
a / R_*	4.62866024	<input checked="" type="checkbox"/>	0.00000000	<input checked="" type="checkbox"/>	1.00000000	1.00000000	1.00000000
T_c	240630.95505021	<input checked="" type="checkbox"/>	240630.95505021	<input checked="" type="checkbox"/>	0.00000000	0.00000000	0.00000000
Inclination (deg)	82.90571240	<input checked="" type="checkbox"/>	0.00000000	<input checked="" type="checkbox"/>	1.00000000	1.00000000	1.00000000
Linear LD v1	0.48800000	<input checked="" type="checkbox"/>	0.48800000	<input checked="" type="checkbox"/>	0.00000000	0.00000000	0.00000000
Quadratic LD v2	0.17000000	<input checked="" type="checkbox"/>	0.17000000	<input checked="" type="checkbox"/>	0.00000000	0.00000000	0.00000000

Calculated from model

Depth	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Scale	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Orbital Inclination	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Planet Radius	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Transit Duration	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Planet Radius	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Excluded Parameters

Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	Weight
ARMA05	-0.0044320431	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
BDL_LRC	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
WPTSL_T1	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
VWPTSL_T1	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
WPTSL_T2	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
VWPTSL_T2	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
WPTSL_T3	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
VWPTSL_T3	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
WPTSL_T4	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
VWPTSL_T4	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
WPTSL_T5	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000
VWPTSL_T5	0.00000000	<input checked="" type="checkbox"/>	0.000000	<input checked="" type="checkbox"/>	0.000000	0.000000	0.000000

Fit Statistics

RMS (mag)	0.044750	chiSq	2.956982	BIC	913.5890	AIC	889	chiSq Target	814.7075
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Fit Optimization

Outer Bound: -33

Inner Bound: -23

Comparison Star Selection: Exhaustive Optimize Max Detrend Pars: 2 Exhaustive Optimize

Iter. Remaining: 0

Min. BIC Thresh.: 2 Iter. Remaining: 0

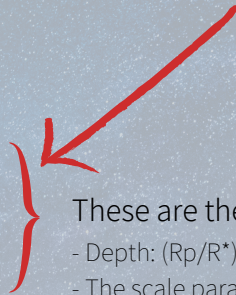
Plot Settings

Show Model Show in Legend Log Optimization

Show Residuals Show in Legend Show Error

Fit Control

Update Fit from



- These are the results of your model:
- Depth: $(R_p/R_*)^2$
 - The scale parameter: a/R_*
 - Orbital Inclination: i
 - Impact parameter: b
 - Full transit duration: T_{14}
 - Planetary radius: R_p
 - Check carefully that the model is realistic and compare them with the expected values !!

AstroImage

2.3) Fitting model

rel_flux_T1

User Specified Parameters (not BIC=0)

Orbital Parameters

Period (day)	0.823	Unit	day
Time of Transit (BJD)	0.0	Unit	BJD
Impact Parameter (b)	0.12	Unit	

Host Star Parameters (enter one)

Star Name	Keck	RA (deg)	20.0	Dec (deg)	0.0	Parallax (mas)	0.0	Distance (pc)	0.0	RA (deg)	0.0	Dec (deg)	0.0	RA (deg)	0.0	Dec (deg)	0.0	RA (deg)	0.0	Dec (deg)	0.0		
RA (deg)	0.0	Dec (deg)	0.0	RA (deg)	0.0	Dec (deg)	0.0	RA (deg)	0.0	Dec (deg)	0.0	RA (deg)	0.0	Dec (deg)	0.0	RA (deg)	0.0	Dec (deg)	0.0	RA (deg)	0.0	Dec (deg)	0.0

Transit Parameters

Enable Trans Fit

Auto Update Prior

Extract Prior Center Values From Light Curve, Orbital, and Fit Markers

Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	MagScale
Baseline Flux (mag)	0.97223394	<input type="checkbox"/>	0.97223394	<input type="checkbox"/>	0.02000000	<input type="checkbox"/>	0.0
γ (mag)	0.02897392	<input type="checkbox"/>	0.02897392	<input type="checkbox"/>	0.02000000	<input type="checkbox"/>	0.0
$\pm F_b$	4.02898294	<input type="checkbox"/>	0.02897392	<input type="checkbox"/>	0.02000000	<input type="checkbox"/>	0.0
T_c	245820.35869212	<input type="checkbox"/>	245820.35869212	<input type="checkbox"/>	0.0	<input type="checkbox"/>	0.0
Inclination (deg)	83.90751647	<input type="checkbox"/>	83.90751647	<input type="checkbox"/>	0.0	<input type="checkbox"/>	0.0
Linear LD u1	0.40830000	<input checked="" type="checkbox"/>	0.40830000	<input type="checkbox"/>	0.0	<input type="checkbox"/>	0.0
Quad LD u2	0.17800000	<input checked="" type="checkbox"/>	0.17800000	<input type="checkbox"/>	0.0	<input type="checkbox"/>	0.0

Calculated from model

Depth (mag)	27.46	IC1 (B)	0.02496	IC2 (B)	0.1343	IC3 (B)	0.03869	IC4 (B)	0.01040	IC5 (B)	0.0376	χ^2 (log)	9.476	Fit (log)	1.14
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Excluded Parameters

Use	Parameter	Best Fit	Lock	Prior Center	Use	Prior Width	Cost	MagScale
<input checked="" type="checkbox"/>	ARMASS	-0.0049320413	<input type="checkbox"/>	0.021	<input type="checkbox"/>	0.0	0.0	0.0
<input type="checkbox"/>	BD_LTC		<input type="checkbox"/>		<input type="checkbox"/>			
<input type="checkbox"/>	BPRT1_T1		<input type="checkbox"/>		<input type="checkbox"/>			
<input type="checkbox"/>	BPRT2_T1		<input type="checkbox"/>		<input type="checkbox"/>			
<input type="checkbox"/>	BPRT3_T1		<input type="checkbox"/>		<input type="checkbox"/>			
<input type="checkbox"/>	BPRT4_T1		<input type="checkbox"/>		<input type="checkbox"/>			
<input checked="" type="checkbox"/>	IC_u1_u2	-0.0000017041	<input type="checkbox"/>	0.021	<input type="checkbox"/>	0.0	0.0	0.0
<input checked="" type="checkbox"/>	Prior_Mean	-0.0000270080	<input type="checkbox"/>	0.021	<input type="checkbox"/>	0.0	0.0	0.0

Fit Statistics

Parallax (mas)	2.044700	dJWahl	2.945900	BIC	979.5890	dJF	300	dJP	913.7075
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Fit Optimization

Exhaustive Optimize Start

Max Detrend Pars.: 1

Min. BIC Thres.: 1

Exhaustive Optimize Start

Rer. Remaining: 0

Fit Settings

Show Model Show in legend Line Color: red Line Width: 2.00

Show Residuals Show in legend Show Error Line Color: red Line Width: 2.00

Symbol: black Dot

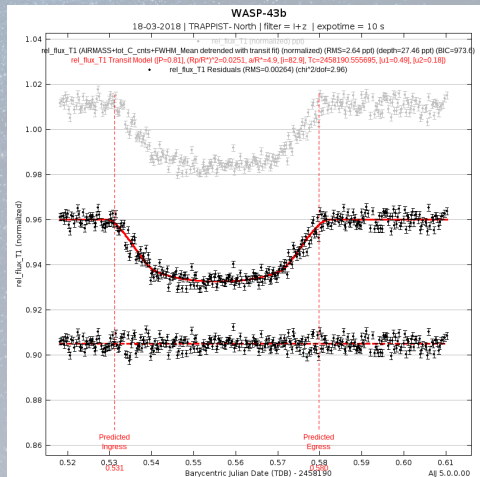
Log Optimization

Fit Control

Auto Update Fit Update Fit from

Fit Tolerance: 1.0E-10

Max Allowed Steps: 25.000 Step Size: 479 |

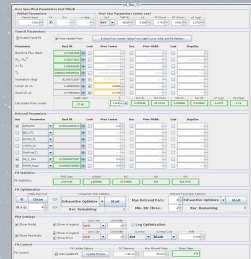
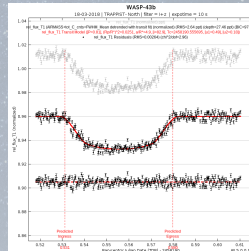
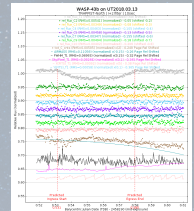
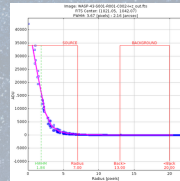
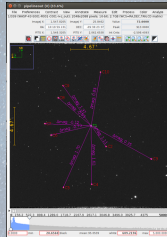


AstroImageJ

2.3) Fitting model

In your final report :

- Depth: $(R_p/R_*)^2$
- The scale parameter: a/R_*
- Orbital Inclination: i
- Impact parameter: b
- Full transit duration: T_{14}
- Planetary radius: R_p
- Check carefully that the model is realistic and compare them with the predictions



Tess Object of Interest Candidates

https://docs.google.com/spreadsheets/d/1WbUW_LZcgKqk9yV3_dEtJ4radUi5o-QfFV3wag1KWP0/edit#gid=0