

Peranso

Downloading and analysing space mission data

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1.0 Introduction

[Peranso](#) (Light curve and Period Analysis Software) is well known to variable star observers but can also be used to download and analyse exoplanet data collected by e.g. [Kepler](#), [Kepler K2](#), [SuperWasp](#) and [TESS](#)

This guide is based on tutorials which can be linked to via the Peranso website or the User Guide under the Help tab in the application.

2.0 Installation


Download and registration can be accessed via the Download and Registration tabs on the Peranso homepage. A single key costs Eur26/\$31.

3.0 Example using TESS data

This is based on

- [Tutorial 18](#)
 - Finding TESS's first planet transiting the naked eye star Pi Mensae
 - Finding the exoplanet - [TOI-1259 A b](#) , as an example which is a K type dwarf star.

3.1 Plotting a TESS light curve

- open Peranso
- select File/New
- click on  and select TESS light curve from the list
- complete the dialogue box and click on Plot to bring up a list of TESS datasets
- check the required number of Import boxes and then Apply to display the data

The various windows mentioned above are shown in Figure 1

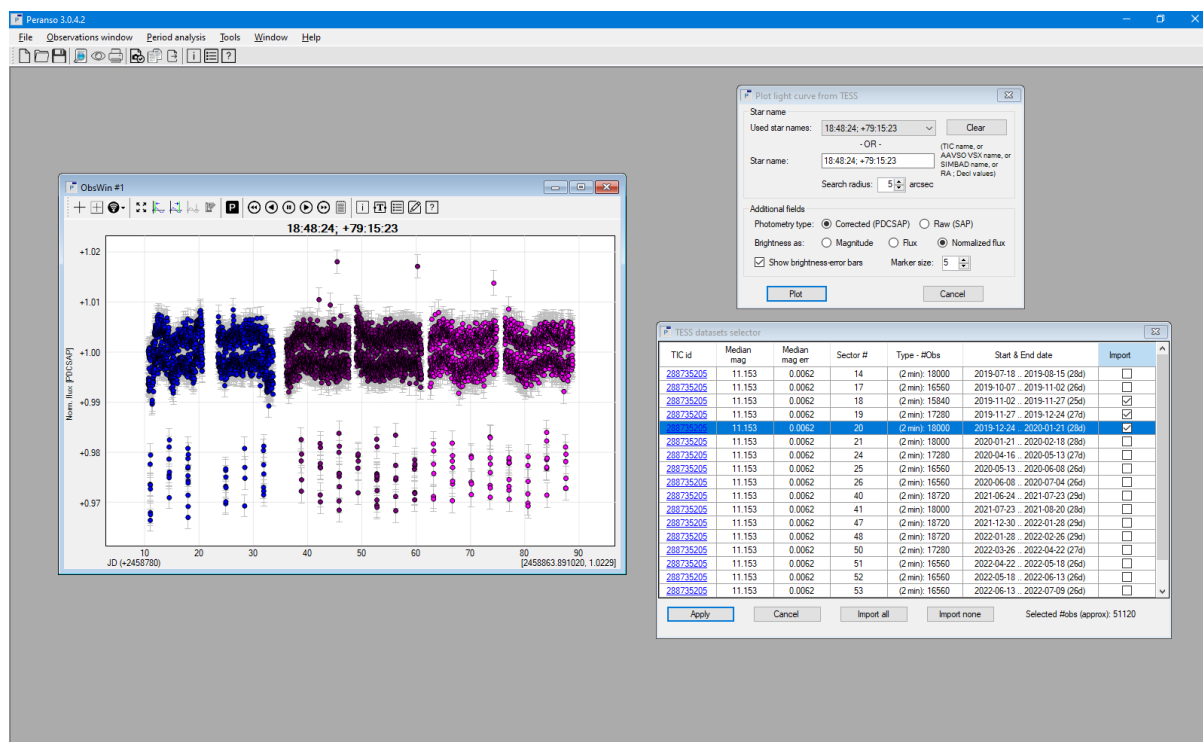


Figure 1. Selecting and displaying TESS data

A phase curve showing two transits is shown in Figure 2

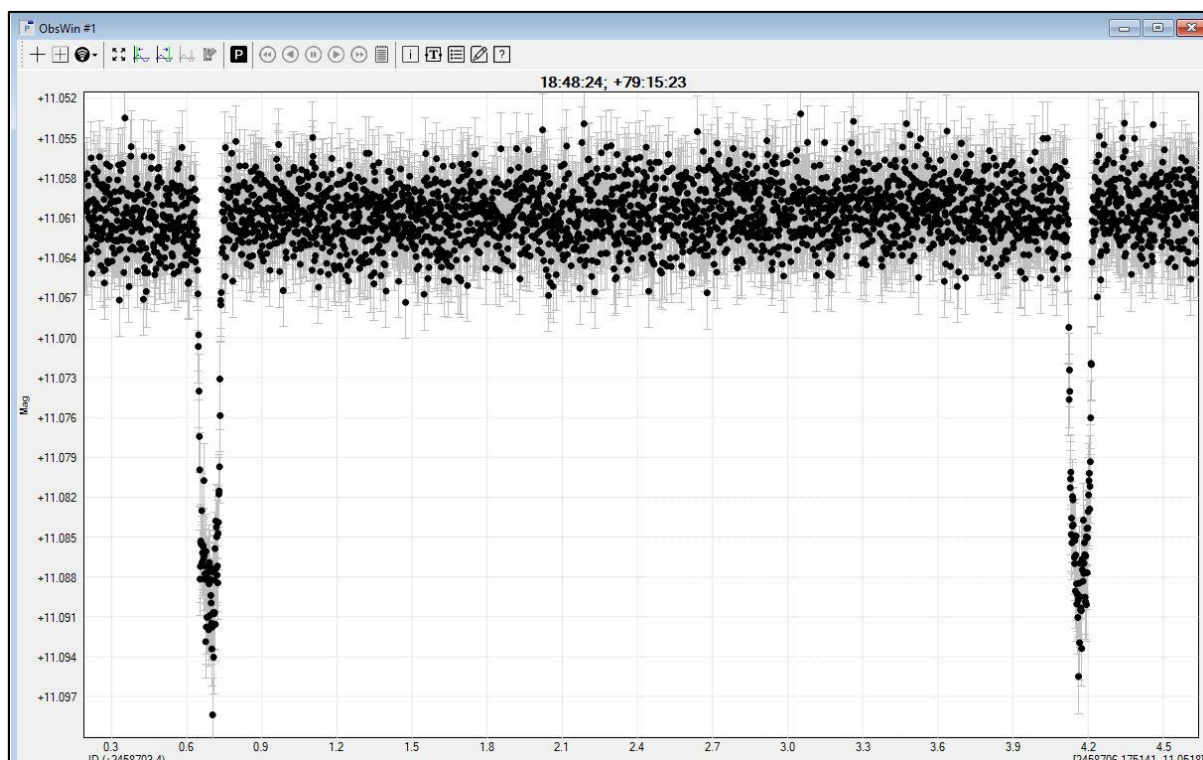


Figure 2. Phase curve

The transits can be zoomed in on – Figure 3

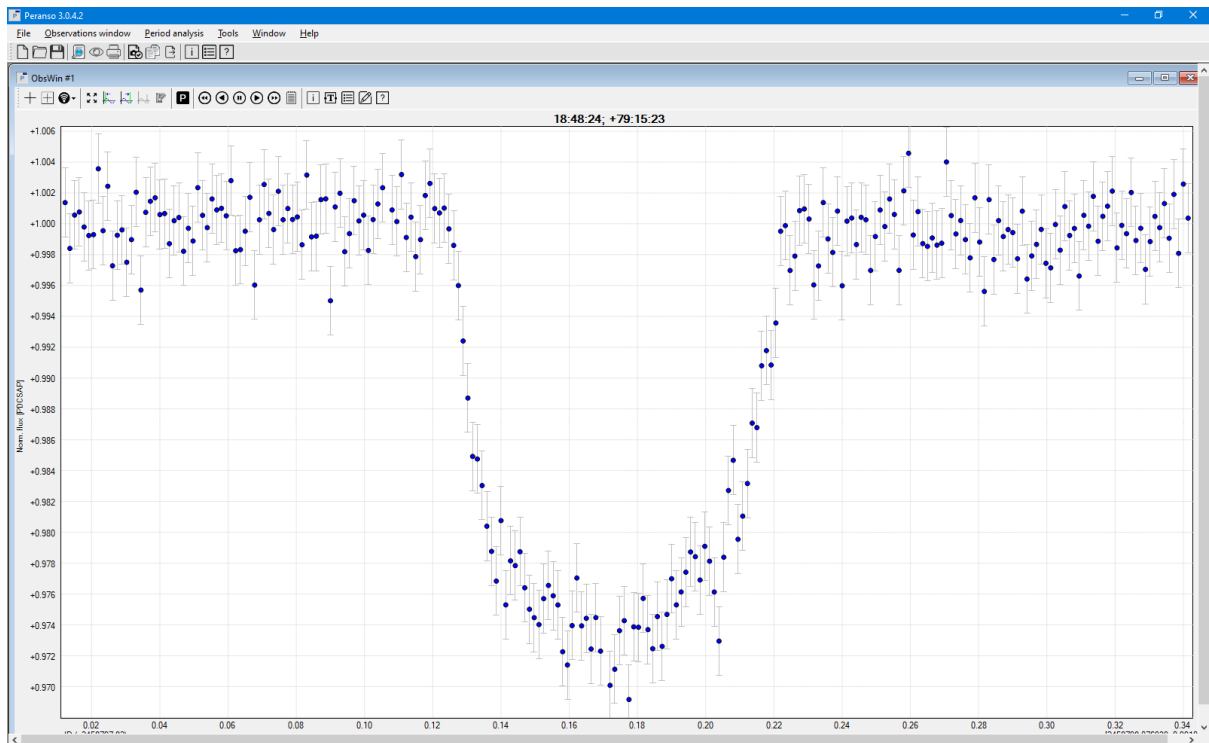


Figure 3. Transit light curve expanded

3.2 Period determination

The orbital period of the exoplanet, time between successive transits, can then be determined.

- select P, Period determination, in the Obswin window
- select EEELS (Edge Enhanced Box-fitting Least Squares) in the Period determination window
- the [ExoKyoto](#) website gives an estimated period of 3.48 days therefore the Range was set at Start = 2 and End = 5
- click on Apply
- the Perwin -EEELS window indicates a prominent period of 3.477 days – very close to the estimated period
- selecting the I, Info box in the Persin-EEELS window brings up further details including a transit duration of 0.0893 days/2.14hrs/128.6 mins. This compares to an example measured transit time of 2.2 days/132 mins. The NASA Exoplanet archive lists the transit time as 2.4754 hrs/149 mins
- select the Perwin-EEELS window and then Period analysis/Phasewin at Frequency cursor value
- zoom in on the transit
- click the right mouse button in the plot area of the Phase Window to display the context menu. Select Show/hide EEELS fit to display the EEELS fit

The various windows mentioned above are shown in Figure 4

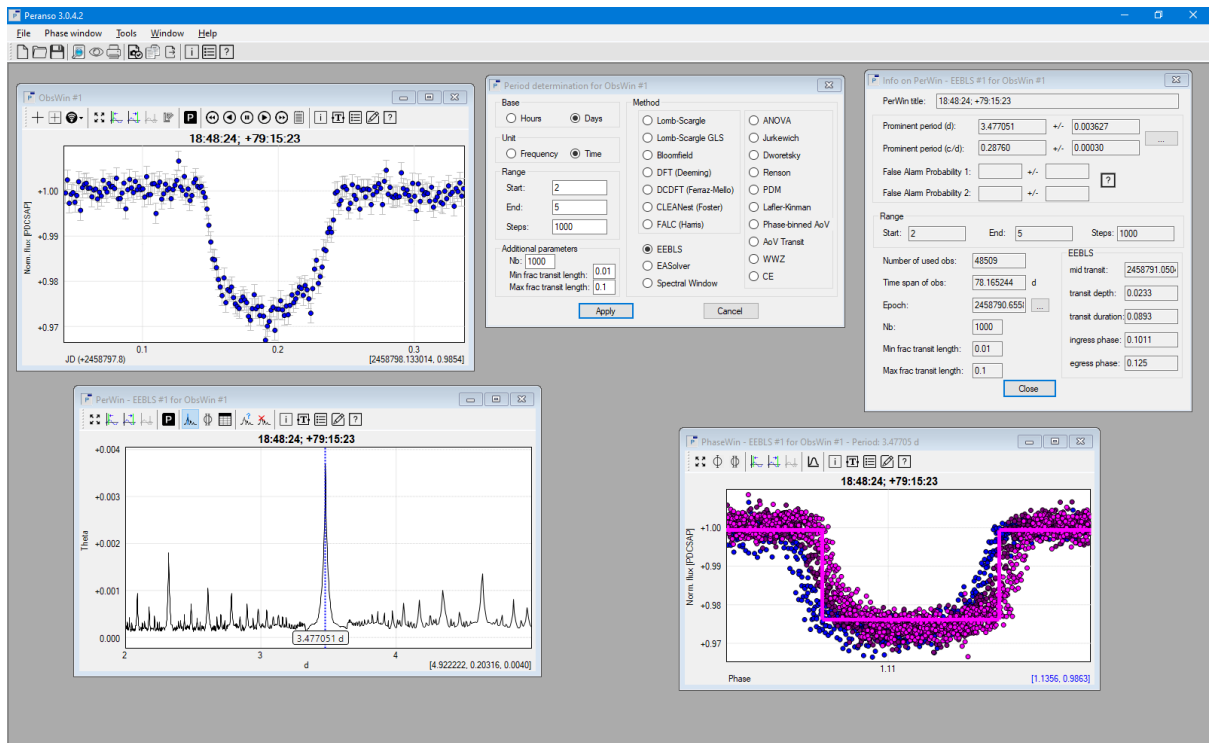


Figure 4. Period determination

3.3 Starspots and exomoons

While viewing the various transits I came across a possible starspot at JD2458690.168383 – Figure 5. Because a planet transits in a few hours and stars rotate over a period of days the starspot is effectively stationary with the planet moving across it during the transit. The starspot is not as bright as the surrounding areas of the photosphere so when the planet transits across it the light-curve gets a little brighter than average and you see a small positive bump in the transit light-curve.

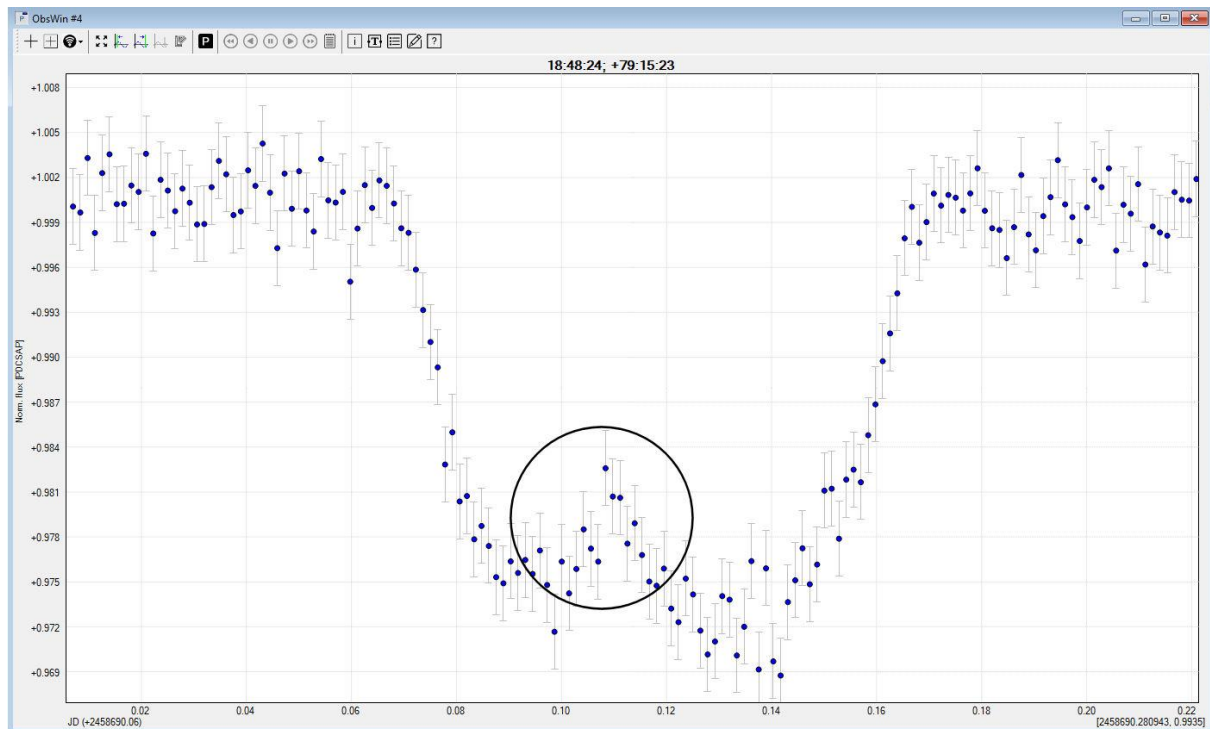


Figure 5. Possible starspot

At JD2458874.504419 there were indications of a moon shown by the increased depth in the latter part of the transit. In this case the moon would be trailing the planet as both transited the host star – Figure 6

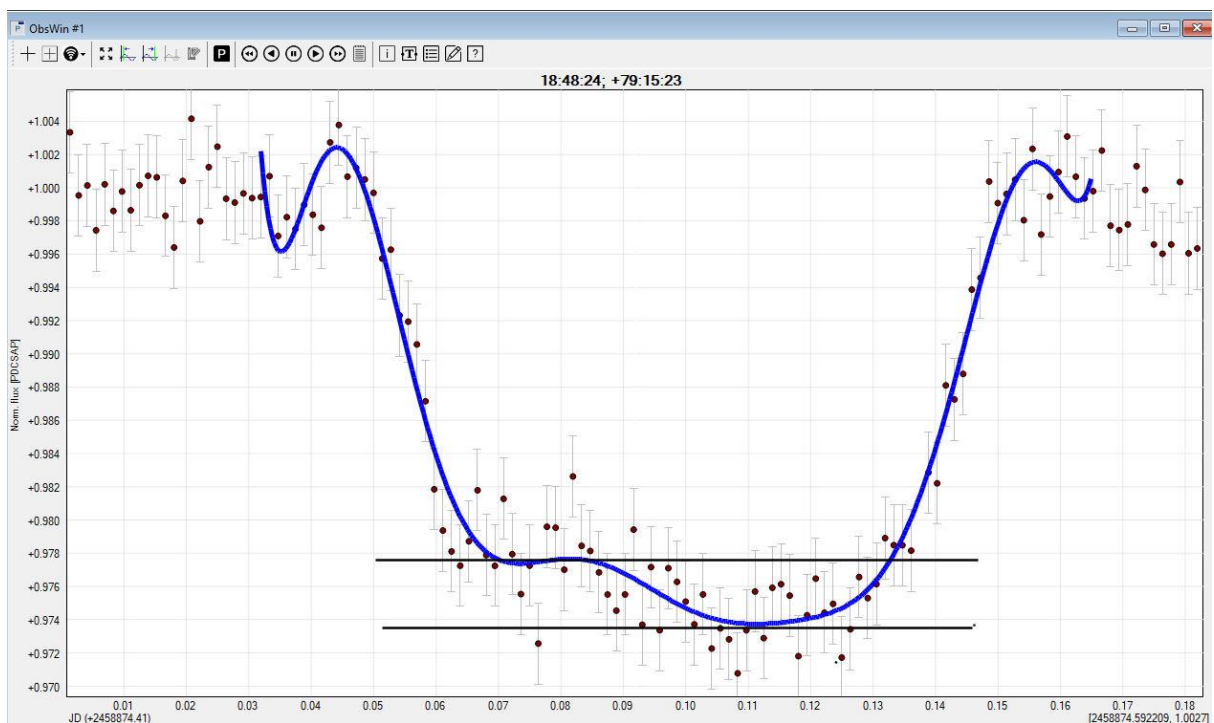


Figure 6. Possible exomoon

The depth variations caused by the presence of a trailing moon are shown by the dotted line in Figure 7

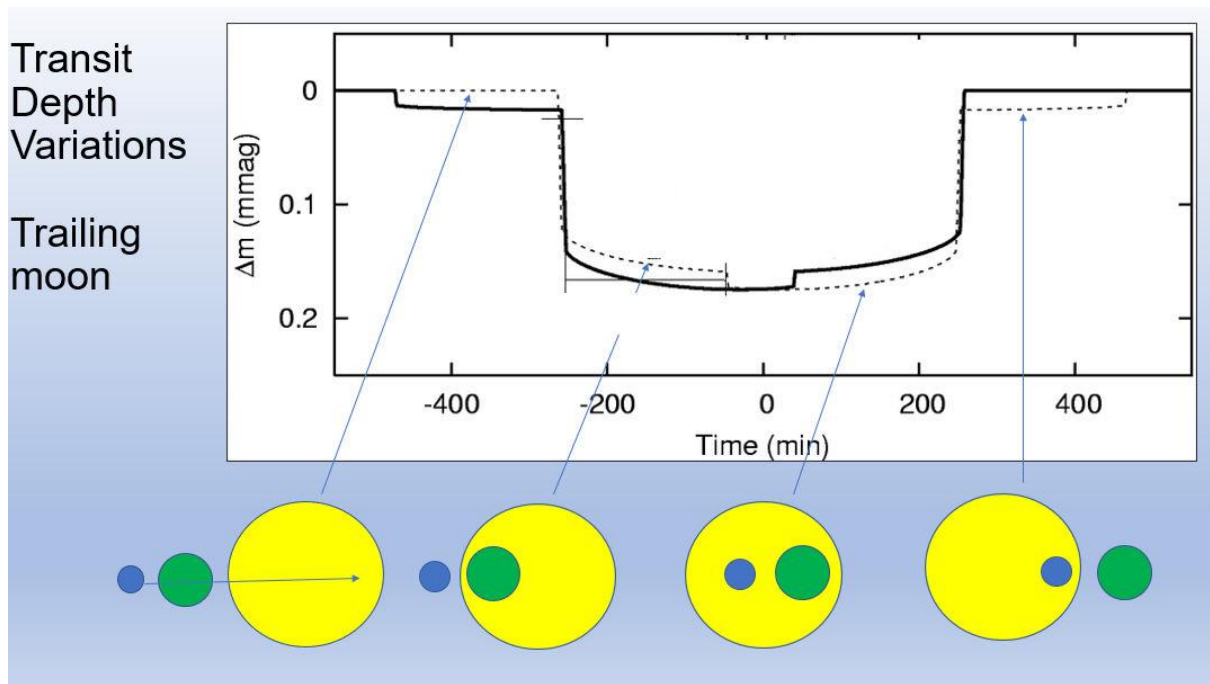


Figure 7. Passage of an exomoon across the host star

4.0 Transit Timing Variations

4.1 WASP-12b data

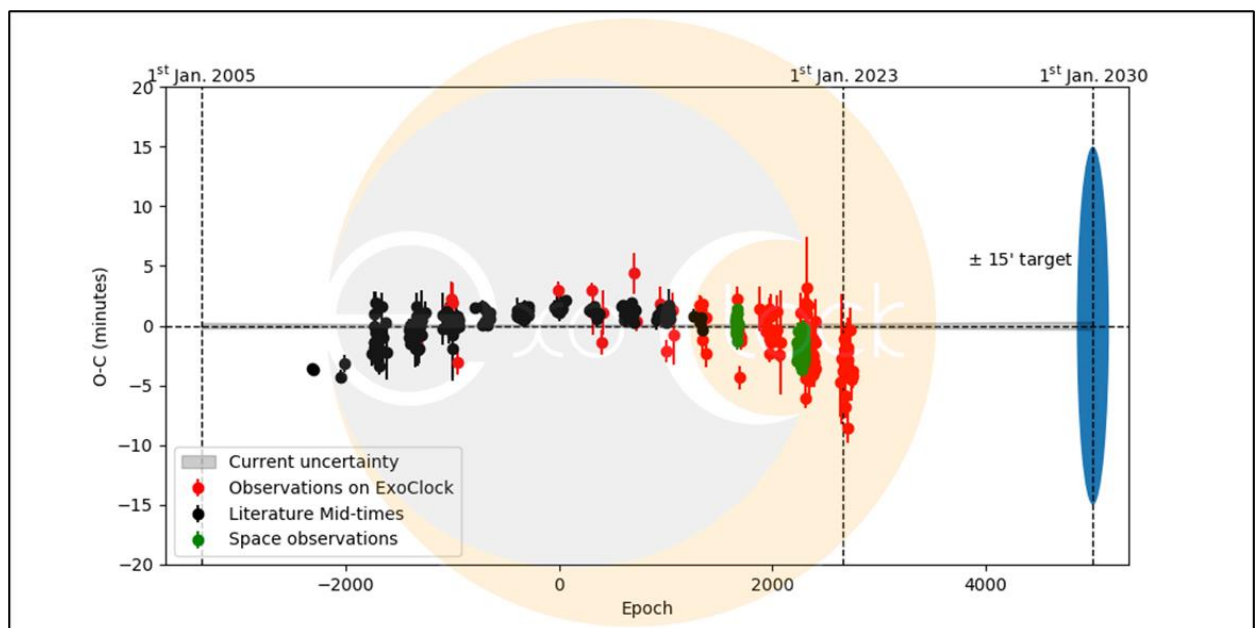


Figure 8. WASP-12b

Credit ExoClock

The variation in (O-C) shown in Figure 8 may be due to e.g.: orbital decay, planetary induced tides, eccentric orbit.

Data from the ExoClock database;

- RA 06:30:32.7966, Dec +29:40:20.266

- transit duration, 3.0 hrs


- transit depth, 17.81 mmag
- mid-time, 2457036.706177 \pm 5.5e-05 BJD TDB
- period, 1.091419179 \pm 4.3e-08 days

Determining the period as in 3.2 above gives the following values;

- transit duration, 0.1047 days/2.51 hrs
- transit depth, 14.3 mmag
- period, 1.091703 days

4.2 Determining transit time variations

4.2.1 Download WASP-12b data from TESS

- open Peranso
- select File/New
- click on  and select TESS light curve from the list
- enter RA and Dec for WASP-12b in star name window
- select Photometry type Corrected (PDCSAP)
- select Brightness as Magnitude
- click on Plot to bring up a list of TESS datasets
- check the required number of Import boxes and then Apply to display the data
- TESS dates are BJD, Barycentric Julian Day, but are converted to BJD to (Geocentric) Julian Day in the Peranso Obswin
- to convert to HJD (which is BJD \pm 4 secs max)
- select ObsSet Properties
- select Apply Helio. Correction
- in the Star identification form enter RA and Dec for WASP-12b then Start
heliocentric correction Heliocentric correction box will be checked on completion
- in ObsSet Properties window click on Apply

Windows are shown in Figure 9 below

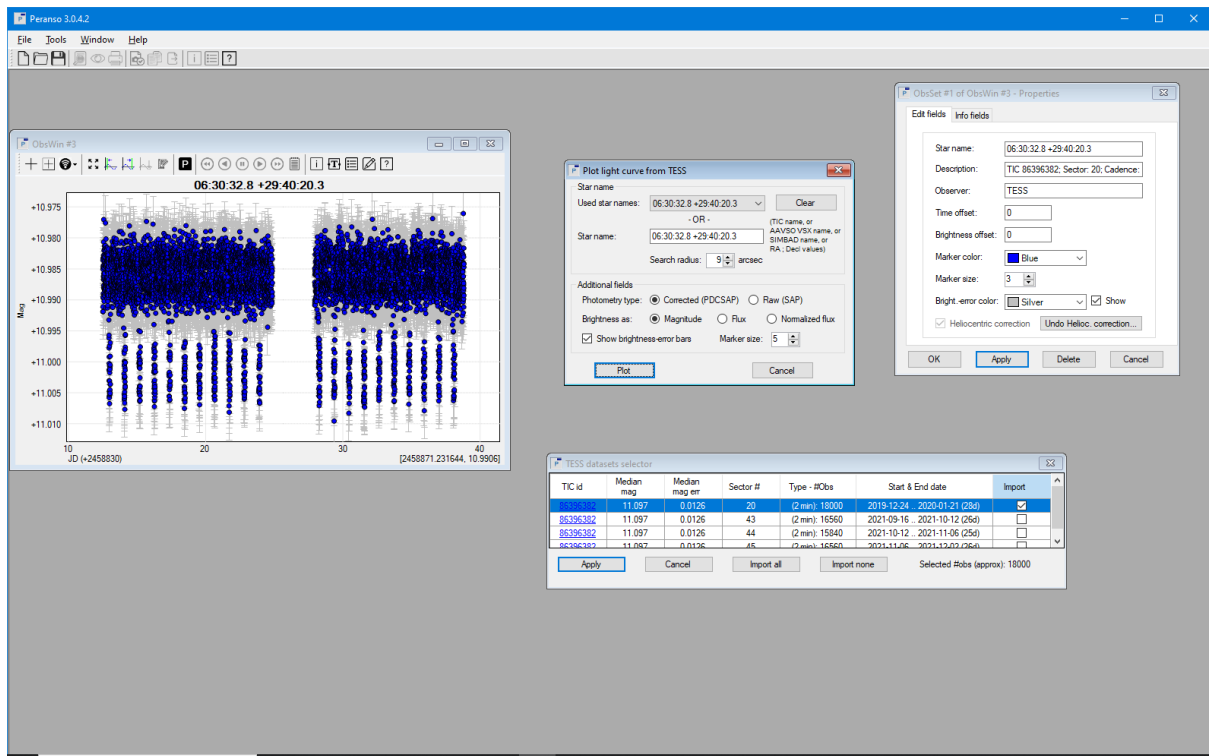


Figure 9. Heliocentric correction applied

4.2.2 Ephemeris calculation

This is based on [Tutorial 15](#), Using the Ephemeris calculator

- select Tools/Ephemeris calculator
- enter object name – WASP-12b
- enter Epoch - 2457036.706177
- in the E box enter period – 1.091419179
- position the cursor over the start and then end of the plot in the ObsWin window to determine the star and end dates and times and enter these in the appropriate boxes and then Calculate

The various windows are shown in Figure 10

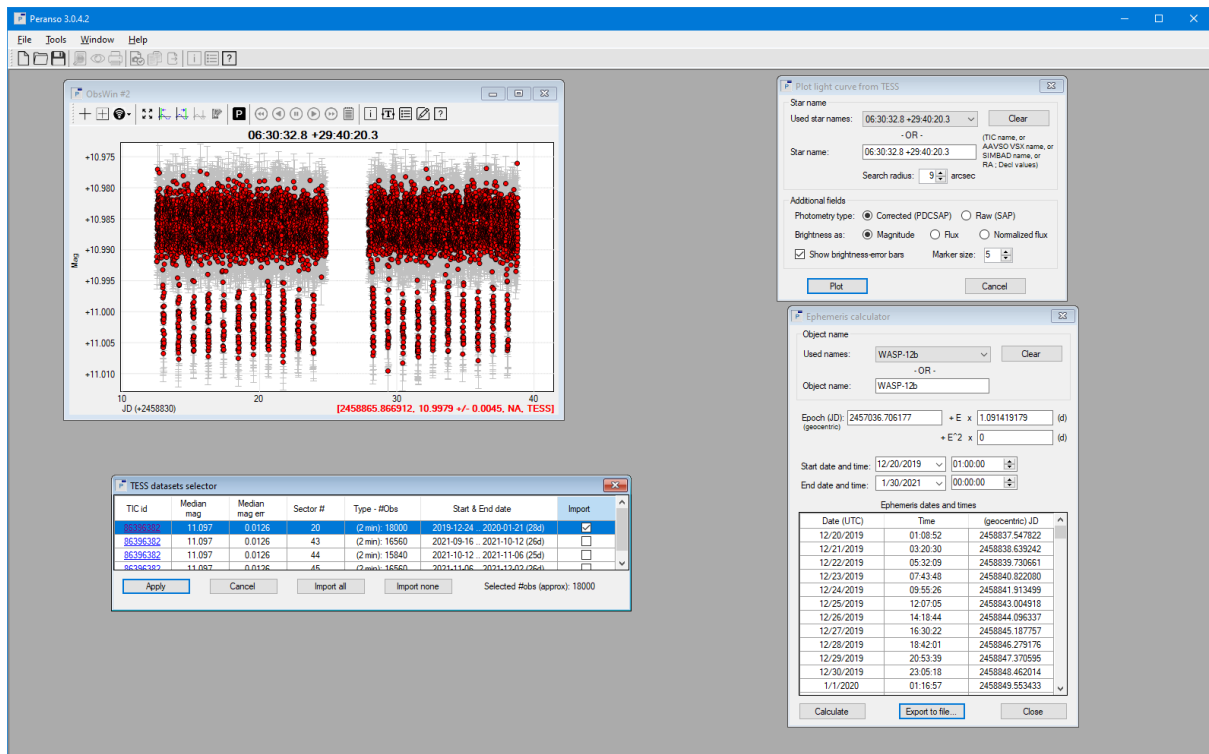


Figure 10. Ephemeris calculation

4.2.3 Determining transit mid-times

This is based on [Tutorial 9, The Kwee-van Woerden method](#)

- in the Obswin draw a box round the first transit to select it
- position the Left and Right margin cursors
- click the Find Extremum button to determine the mid-point of the transit
- copy value to Excel spreadsheet
- delete margin cursors
- return to Full view and repeat for each transit
- TESS dates are BJD, Barycentric Julian Day, but are converted to Geocentric Julian Day in the Peranso Obswin
- the difference between HJD and BJD is up to ± 4 secs so HJD is accurate enough as transit time (O-C) is measured in minutes

The various windows are shown in Figure 11

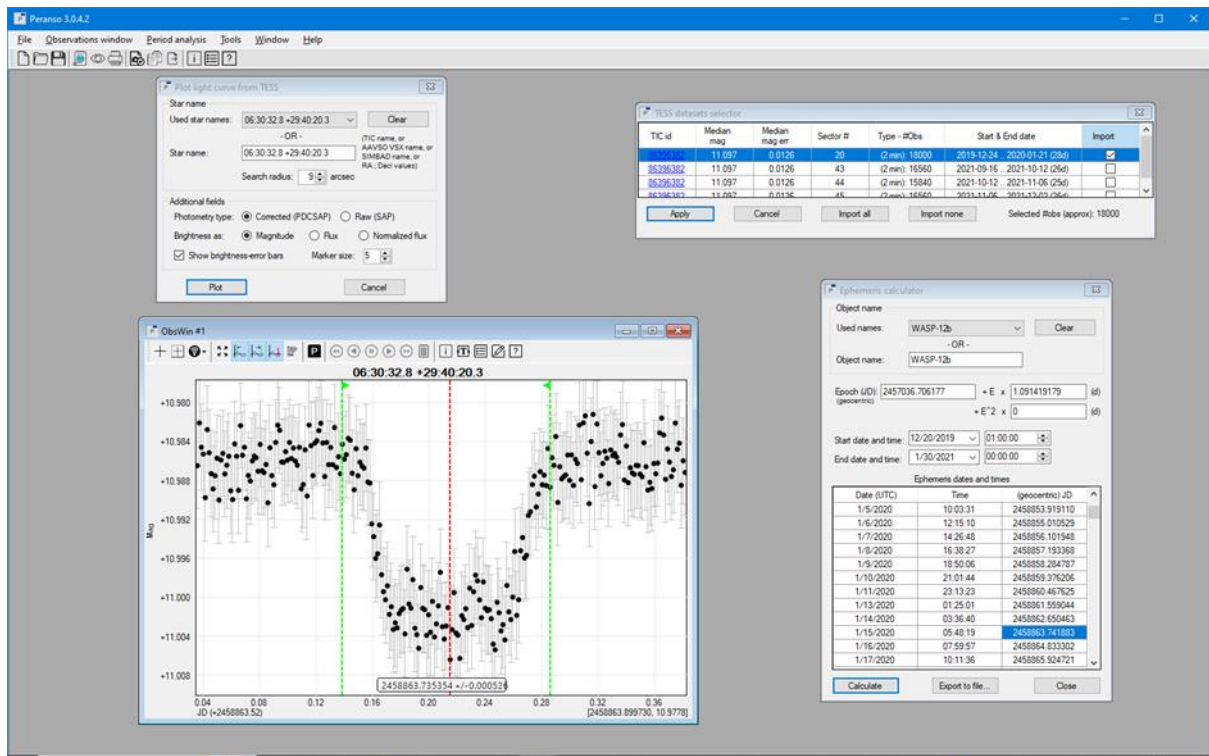


Figure 11. Transit mid-time determination

4.2.4 Plotting data in Excel

List measured Times of Minima (HJD) (O)

List ephemeris (HJD) (C)

Calculate (O-C)

Plot (O-C) – Figures 11, 12

Good comparison with ExoClock data and slight orbital decay shown

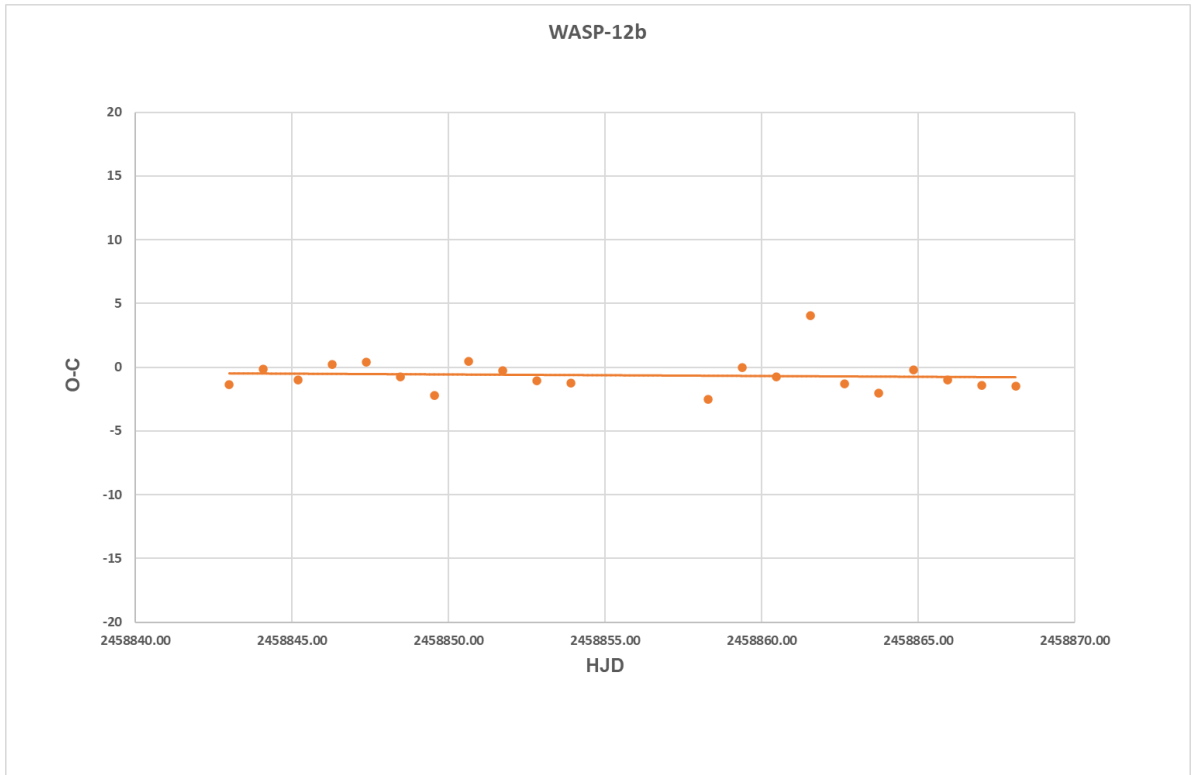


Figure 11. O-C

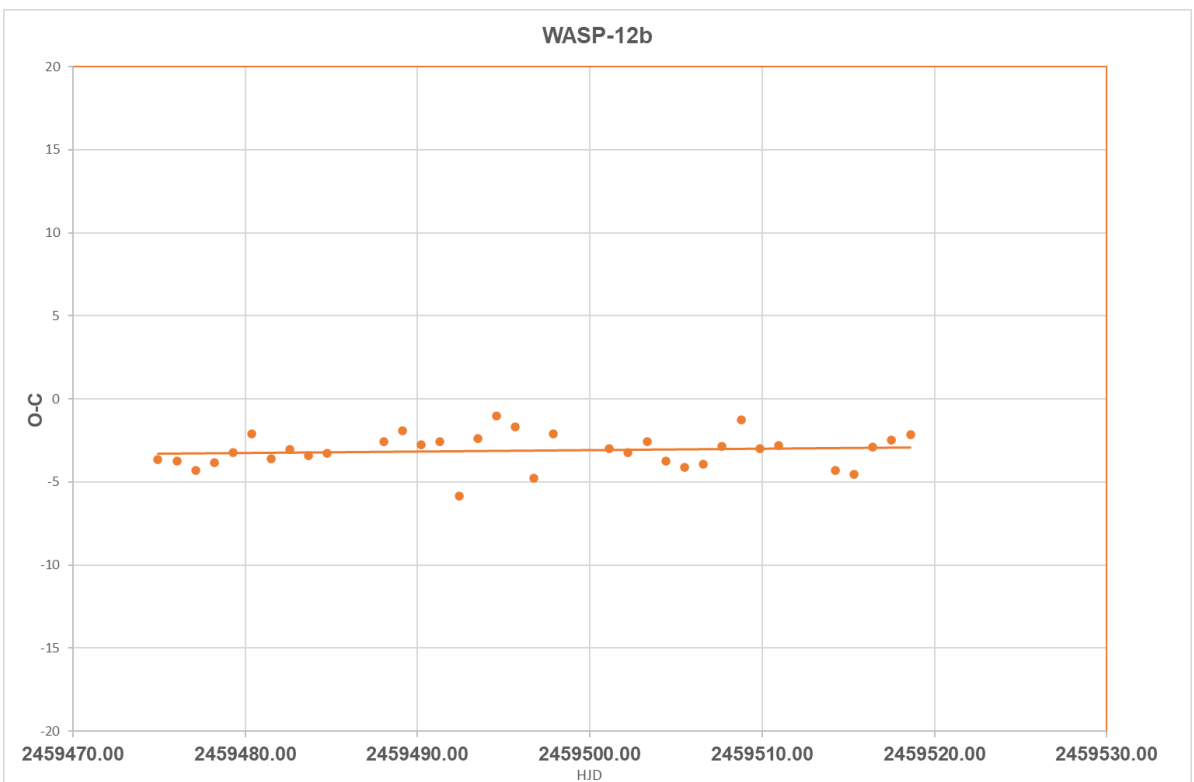


Figure 12. O-C

5.0 Relative positions of the Earth, Sun and WASP-12b

Figure 13 shows how (O-C) varies with the position of the Earth in its orbit.

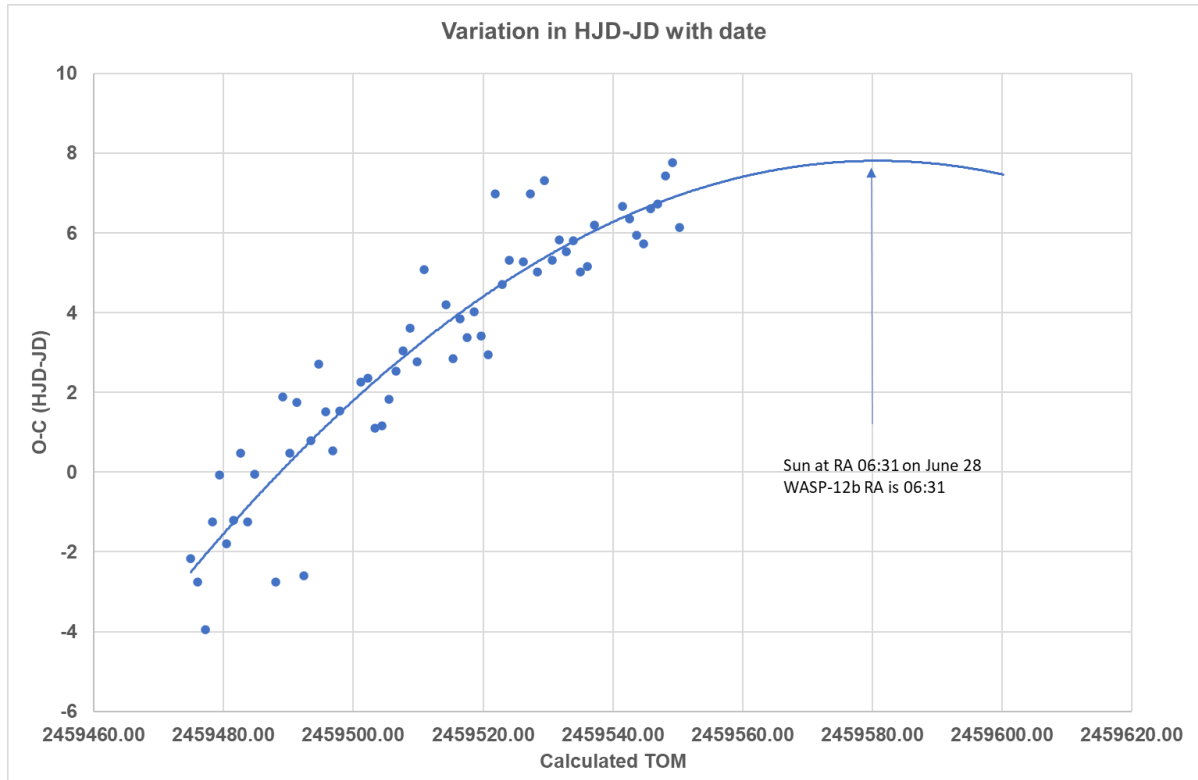


Figure 13. Variation in (O-C) with the orbital position of the Earth.

At JD 2459490 there is zero difference between (O-C) whether or not the measurement is done in JD or HJD.

At JD 2459550 the difference is near to its maximum of 8 mins which it reaches at JD 2459580, the Earth being on the opposite side of the Sun to WASP-12b.

The relationship in the positions of WASP-12b, the Sun and the Earth is shown in Figure 14

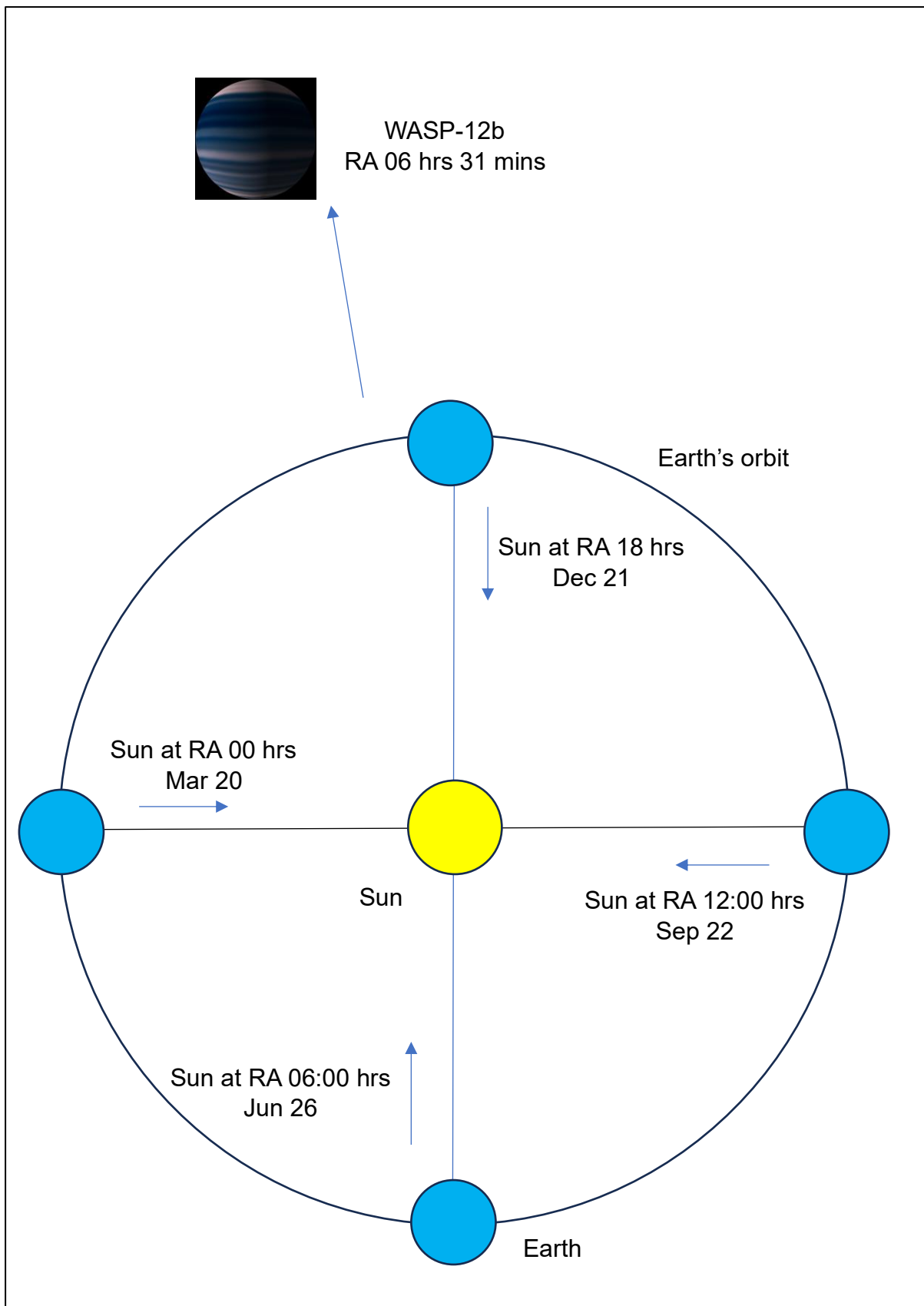


Figure 14. Relative positions of the Earth, Sun and WASP-12b