Leon Liu and Peter Plavchan

Department of Physics and Astronomy, 4400 University Drive MS 3F3, George Mason University, Fairfax, VA 22030, USA

23 July 2024

TOI 5907.01

Abstract

TOI 5907.01 is a candidate exoplanet identified by TESS (Transiting Exoplanet Survey Satellite) during its mission to search for other planets outside of our solar system. This study aims to investigate whether a transit occurs on the star at the expected time. The data of TOI 5907.01 was obtained from the observatory at George Mason University, and the software AstroImageJ was used to reduce the data, plate-solve, and light-curve creation. After generating the light curve, the data had been off from what was predicted where the dip happened after the predicted ingress and egress making the result inconclusive.

1. Introduction

Exoplanet transits refer to when a planet passes in front of its host star seen from Earth, when the planet passes in front of the star it leads to a temporary dip in the star's brightness. This method of detecting and studying exoplanets has become one of the most effective ways of discovering them. TESS or Transiting Exoplanet Survey satellite has been conducting surveys throughout the sky in order to identify over 5500 exoplanets or TESS Objects of Interest (TOI). While the TESS missions have greatly expanded from only one object found in 1992 to over

5500 objects 31 years later, many questions remain unanswered about the diversity and characteristics of these different exoplanets. In this paper, we present follow-up observations of TOI 5907.01, the TESS candidate orbiting a star that has a stellar radius of approximately 1.080. These observations aim to investigate whether transit occurs on the star at the expected time. In Section 2, we present our observations from TESS and the George Mason University 0.8m telescope. In Section 3, we present our tools used for the analysis of the TESS light curve for TOI 5907.01 and our ground-based light curve analysis. In Section 4, we present our light curve results. In Section 5 we discuss our results and in Section 6 we present our conclusions and future work.

2. Observation

In Section 2.1 we present the TESS Object of interest TOI 5907.01 and its exoplanet candidate properties, its host star properties from the TESS Input Catalog, the *Gaia* mission, and other archival sources. In Section 2.2 we present a summary of the observational data collected with the George Mason University 0.8m telescope.

TOI 5907.01 had 228 exposures before and 219 after data reduction with each image having 80 seconds of exposure and a period of 0.66 days lasting from 2023/07/10 at 21:46 to 2023/07/11 at 04:42. TOI 5907.01 had a stellar effective temperature of 5766 Kelvins (K) and a stellar radius of 1.080 R* (Rsun).

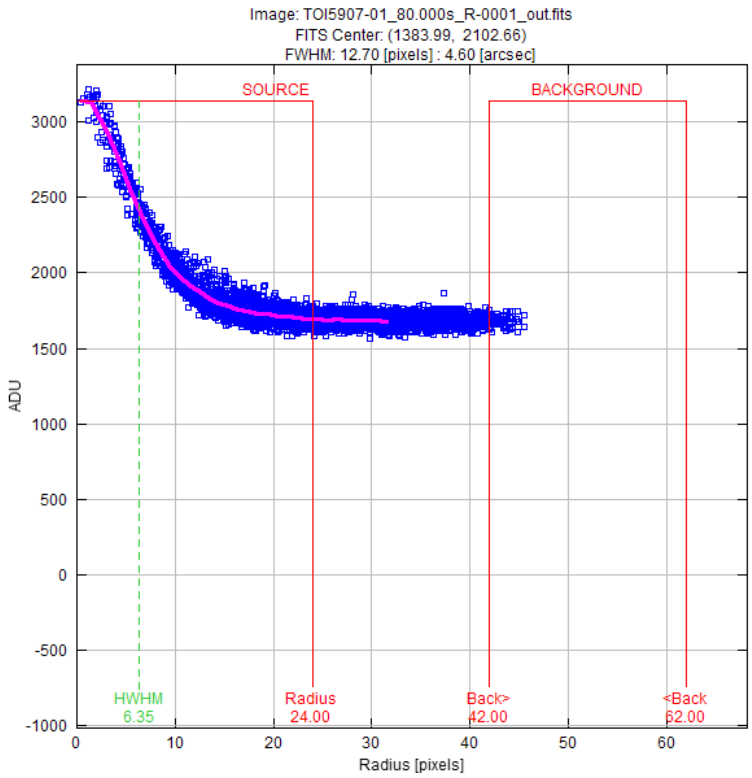
TOI 5907.01 was observed using a red filter (R) and had an RA and DEC of 21h00m52.77s and +17d06m59.10s

3. Analysis

In Section 3.1 we present our tools used to analyze the TESS sector light curve using AstroImageJ. In Section 3.2 we present our analysis of the ground-based light curve using AstroImageJ.

The tools we used to create the TESS sector light curve were AstroImageJ for the data-reduction process, generating a measurements table, and the light curve image. ANSVR for plate-solving the data-reduced science images.

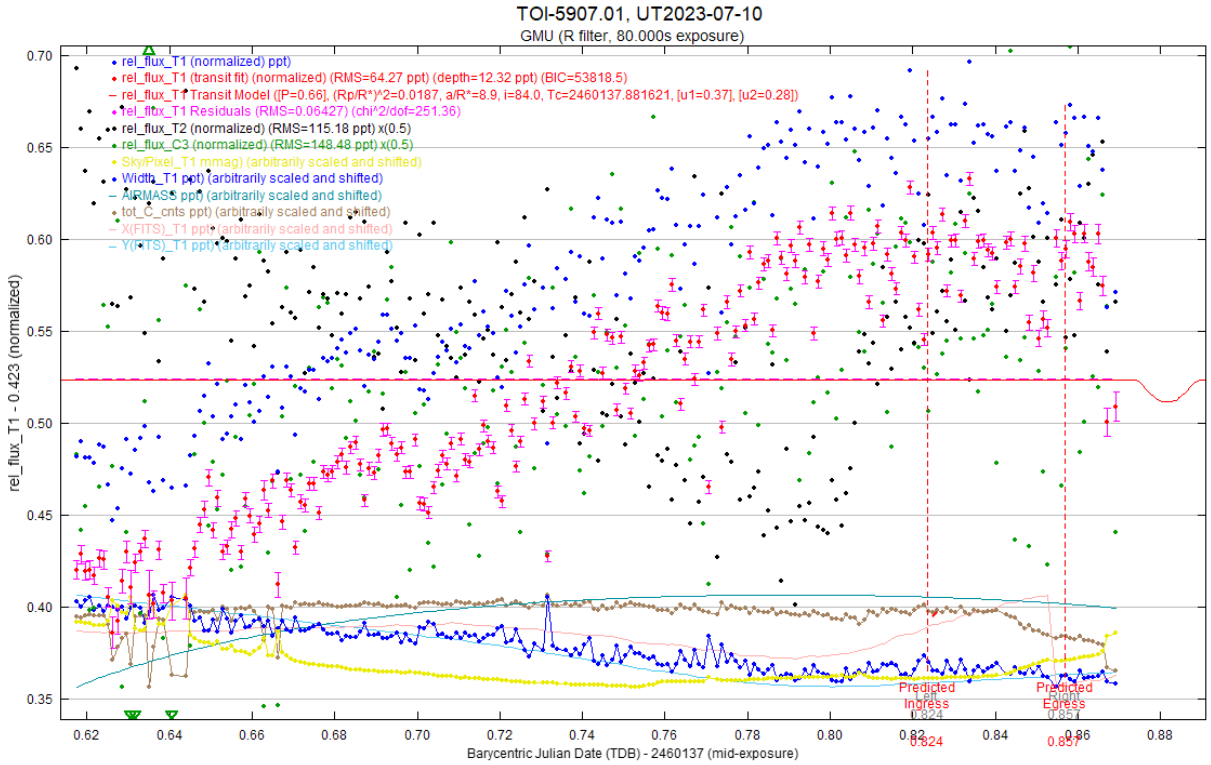
First, we downloaded the 228 exposures and then manually went through each science image to remove faulty images that were blurred or smudged. Then, we used AstroImageJ's CCD Data Processor to conduct the data-reduction process, creating the master dark and the master flat file used for data-reducing. At first, we tried to align the images, however, this process did not turn out successful for us due to us not being able to find out where the RA and DEC coordinate was. Next, we tried another process, plate-solving, using the software ANSVR which allowed us to center the images around the given RA and DEC coordinates and create a more accurate light curve. Then, we generated a seeing profile that allowed us to determine the radius, inner annuli, and outer annuli of the star:

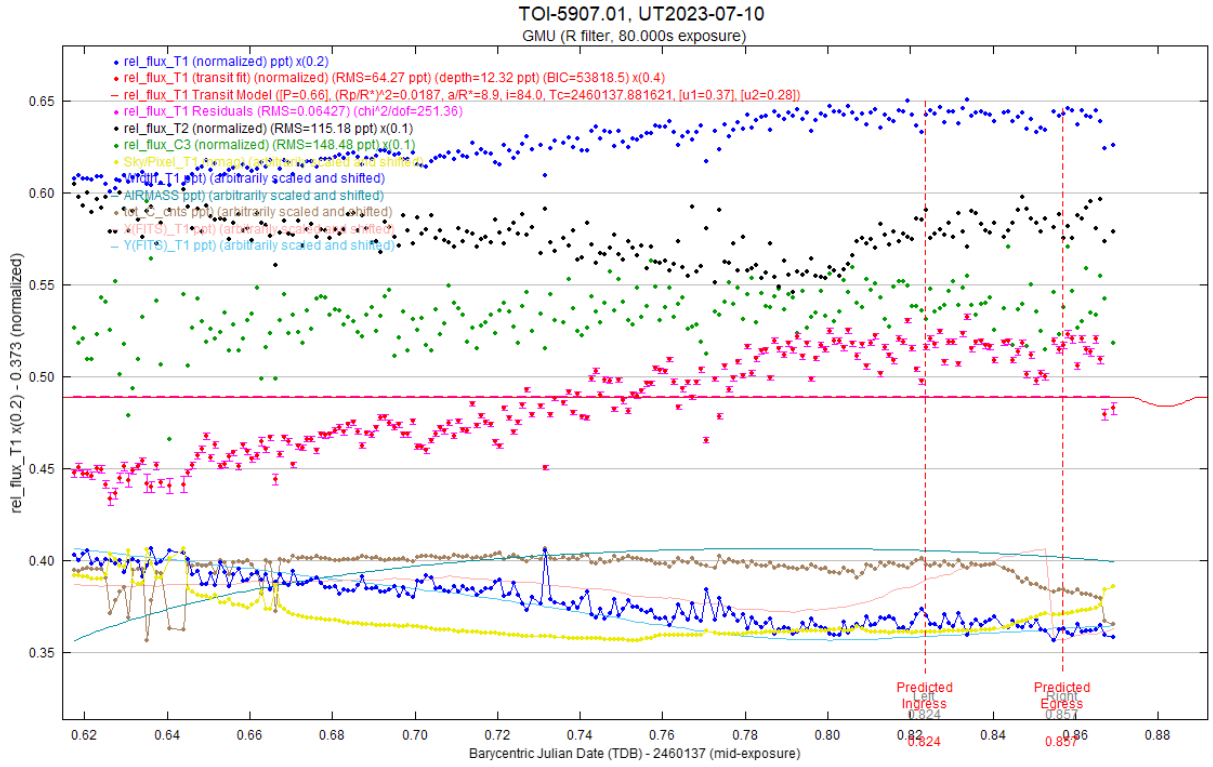


After, we used multi-aperture photometry to generate our measurement table used to generate the lightcurve. Then, we used the star's stellar surface gravity, effective temperature, and metallicity to determine the Linear LD u1 and Quad LD u2 values. Using the data value we created the lightcurve.

4. Results

In Section 4 we present the data from the light curve generated from AstroImageJ. The results point towards that there might be transit at the given ingress and egress times from the relative flux equalizing at the given times; however, the relative flux transit fit shows a clear dip, but it is off the predicted ingress and egress time, leaving the data to be inconclusive but hints at a transit.


TOI-5907.01, UT2023-07-10
GMU (R filter, 80.000s exposure)
rel_flux_T1 (normalized) ppt
rel_flux_T1 (transit fit) (normalized) (RMS=64.27 ppt) (depth=12.32 ppt) (BIC=53818.5)
rel_flux_T1 Transit Model ([P=0.66], (Rp/R*)^2=0.0187, a/R*=8.9, i=84.0, Tc=2460137.881621, [u1=0.37], [u2=0.28])
rel_flux_T1 Residuals (RMS=0.06427) (chi^2/dof=251.36)
rel_flux_T2 (normalized) (RMS=115.18 ppt) x(0.5)
rel_flux_C3 (normalized) (RMS=148.48 ppt) x(0.5)
Sky/Pixel_T1 mmag) (arbitrarily scaled and shifted)
Width_T1 ppt) (arbitrarily scaled and shifted)
AIRMASS ppt) (arbitrarily scaled and shifted)
tot_C_cnts ppt) (arbitrarily scaled and shifted)
X(FITS)_T1 ppt) (arbitrarily scaled and shifted)
Y(FITS)_T1 ppt) (arbitrarily scaled and shifted)
rel_flux_T1 - 0.423 (normalized)
Barycentric Julian Date (TDB) - 2460137 (mid-exposure)
Predicted Left Ingress 0.824
Predicted Right Egress 0.857


TOI-5907.01, UT2023-07-10
GMU (R filter, 80.000s exposure)
rel_flux_T1 (normalized) ppt x(0.2)
rel_flux_T1 (transit fit) (normalized) (RMS=64.27 ppt) (depth=12.32 ppt) (BIC=53818.5) x(0.4)
rel_flux_T1 Transit Model ([P=0.66], (Rp/R*)^2=0.0187, a/R*=8.9, i=84.0, Tc=2460137.881621, [u1=0.37], [u2=0.28])
rel_flux_T1 Residuals (RMS=0.06427) (chi^2/dof=251.36)
rel_flux_T2 (normalized) (RMS=115.18 ppt) x(0.1)
rel_flux_C3 (normalized) (RMS=148.48 ppt) x(0.1)
Width_T1 ppt) (arbitrarily scaled and shifted)
AIRMASS ppt) (arbitrarily scaled and shifted)
Y(FITS)_T1 ppt) (arbitrarily scaled and shifted)
rel_flux_T1 x(0.2) - 0.373 (normalized)
Barycentric Julian Date (TDB) - 2460137 (mid-exposure)
Predicted Left Ingress 0.824
Predicted Right Egress 0.857

5. Discussion

In Section 5.1 we present our interpretation of our results. In Section 5.2 we place our results into the context of the greater field of follow-up of candidate exoplanets from the NASA TESS mission.

When examining the two light curves it appears that there isn't a transit due to data overlapping the predicted ingress and egress; however, upon inspecting closer some parts of the data may hint towards a transit exoplanet. In the first light curve, there is a noticeable equalization of the data in the relative flux as well as other references; furthermore, the relative flux transit line also shows a noticeable dip in the straight line which indicates that something had blocked the light, however, the dip is seen to be off the predicted ingress and egress which may leave the data to be inconclusive.

Though the transit exoplanet that we chose didn't receive as accurate data as we hoped, the dip in the light curve could also signify another exoplanet that is orbiting the star because the predicted ingress and egress are far off from each other which shows that there may not be transit for that certain exoplanet; however, the other dip may be caused from another exoplanet near the star.

6. Conclusion and Future Works

In conclusion, we weren't able to 100% define that there was a transit at TOI 5907; however, the data can point towards another exoplanet within the area due to the delayed dip in the light curve. In the future, a more accurate metallicity can help determine the Linear LD u1 and Quad LD u2 values which can improve upon the data produced. Secondly, there can be

another observation on the same TESS object that could be looking for another exoplanet orbiting the host star.

Works Cited

1. https://exoplanetarchive.ipac.caltech.edu/overview/TOI5907
2. https://exofop.ipac.caltech.edu/tess/target.php?id=387318486
3. https://exoplanets.nasa.gov/news/1767/discovery-alert-with-six-new-worlds-5500-discovery-milestone-passed/
4. https://astroutils.astronomy.osu.edu/exofast/limbdark.shtml