Ground-Based Follow-Up Validation Observations of TESS Object of Interest TOI 5907.01

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Abstract

This study analyzes the candidate exoplanets and their host stars, the data of which was gathered by the NASA Transiting Exoplanet Survey Satellite, and the ground-based observations from the George Mason University Satellite. In particular, we focused on the exoplanet TOI 5907.01, which orbits the star TOI 5907. We used this data to plate-solve and perform multi-aperture photometry to analyze light curves. The goal of this study is to confirm the planetary nature of this exoplanet based on the transit in the light curve. We were unable to confirm, which suggests that TOI 5907.01 was a false positive and not a real exoplanet.

Introduction

The search for exoplanets, or planets that are outside of our solar system, is led by NASA's Transiting Exoplanet Survey Satellite (TESS) mission. First, they collect data in the sky using four high-tech cameras. They detect candidate exoplanets–which are called TESS Object of Interest (TOI)--by observing a transit in their light path. Later, ground-based observation conducted on Earth is required to confirm whether they are real exoplanets and not false positives. Of the thousands of candidate exoplanets, only a few hundred have been confirmed.

This is important in our ever-lasting quest to find life outside of Earth, since we can find exoplanets that have similar measurements as Earth. For example, a study in 2024 presented TOI 1685 b as a confirmed exoplanet that has a similar makeup to Earth but is about three times bigger. They revisited this planet after discovering inconsistencies in previous data. Another study done by Jose Manuel Almenera (2023) confirmed the planetary nature of TOI 4860. They discovered that this exoplanet has a similar size and mass to Saturn.

We deal with the exoplanet TOI 5907.01. There aren't other papers published that detail this particular exoplanet, so it hasn't been confirmed yet. In this paper, we present follow-up observations of TOI 5907.01, which has a period of 0.66 days, and a radius of 8.315 solar radii. The goal of this study is to determine if the transit occurs on the expected star at the expected time, with the according length and depth.

In Section 2, we present our Observations from TESS and the George Mason University 0.8m telescope. In Section 3, we present our 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.

Observations

In Section 2.1 we present the TESS Object of Interest 5907.01 and its properties, from NASA archives. In Section 2.2, we present a summary of the observational data collected with the George Mason University 0.8m telescope.

2.1

TOI 5907.01's right ascension, or RA, is 21h00m52.77s, and the declination, or Dec, is +17d06m59.10s. RA and Dec are used to measure where the object is in the sky, like longitude and latitude. Its predicted transit depth is 4.06 mmag.

2.2

From George Mason University's 0.8 mm telescope, 172 science images were collected of TOI 5907.o1, each with an exposure time of 90 seconds. These images were taken on July 28, 2024, from 9:50 pm to 4:35 am the next day. They were taken with the R filter. There were also 10 dark and 10 flat images taken, with the darks' exposure being 90 seconds and the flats' being 3 seconds.

Analysis

Section 3.1 presents the tools used to analyze the TESS light curve using the astronomical software AstroImageJ (AIJ). In section 3.2, we present our analysis of the ground-based light curve using AstroImageJ.

3.1

First, we went through all the science images and got rid of any that showed streaking, had no stars, or were overall bad quality. Then we created a master dark and flat using the AstroImageJ DP Coordinate Converter and CCP Data Processor windows. We used the master dark and flat to reduce and plate-solve to align all the images.

3.2

With the plate-solved images, we used aperture photometry to generate a light curve. Using the seeing profile from the AIJ plugins menu, we adjusted the settings of the object aperture and inner/outer annulus sizes(Figure 1). They were 29, 50, and 75 pixels, respectively.

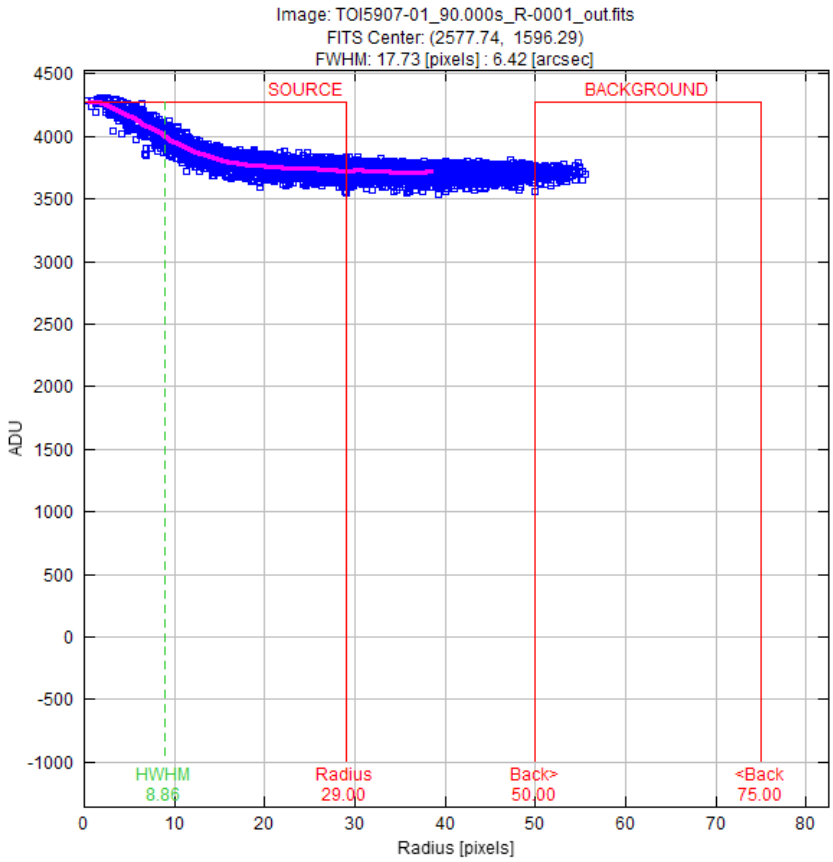

Figure 1. Seeing Profile of TOI 5907.01, which was used for Aperture Photometry Settings

Then, AIJ automatically placed 11 reference stars, along with the stars imported from the GAIA files (Figure 2). These were used to generate a measurement table, which can be turned into a light plot.

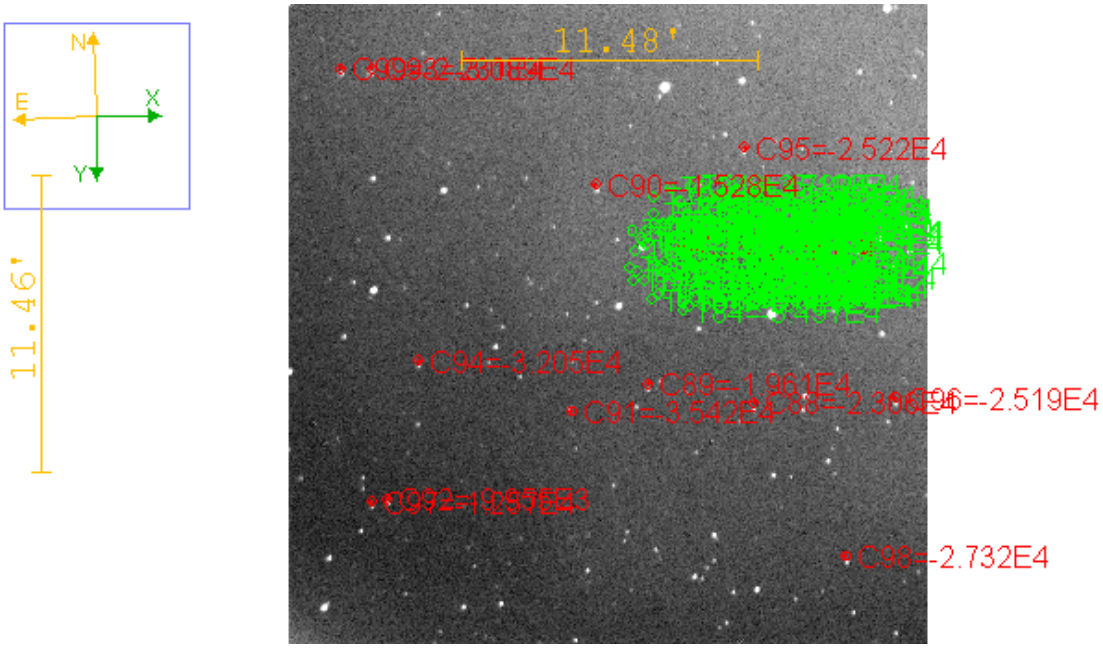

Figure 2. The reference stars selected for TOI 5907.01

The AIJ multi-plot tool was used to analyze the light curve. We changed the default X-data to BJD_TBD and entered the predicted ingress and egress times. Next, in the Data Set 2 Fit Settings window in AIJ, we entered the target's period(o.65 days) and stellar radius (8.315 solar radii). We then go to the Multi-Plot Y Data window and plotted Sky/Pixel_T1, Width_T1, AIRMASS, tot_C_cnts, X(FITS)_T1, Y(FITS)_T1 with the according TFOP SG1 Guidelines.

Results

In section 4.1, we present the ground-based light curve that was generated for TOI 5907.01.

4.1

Figure 3

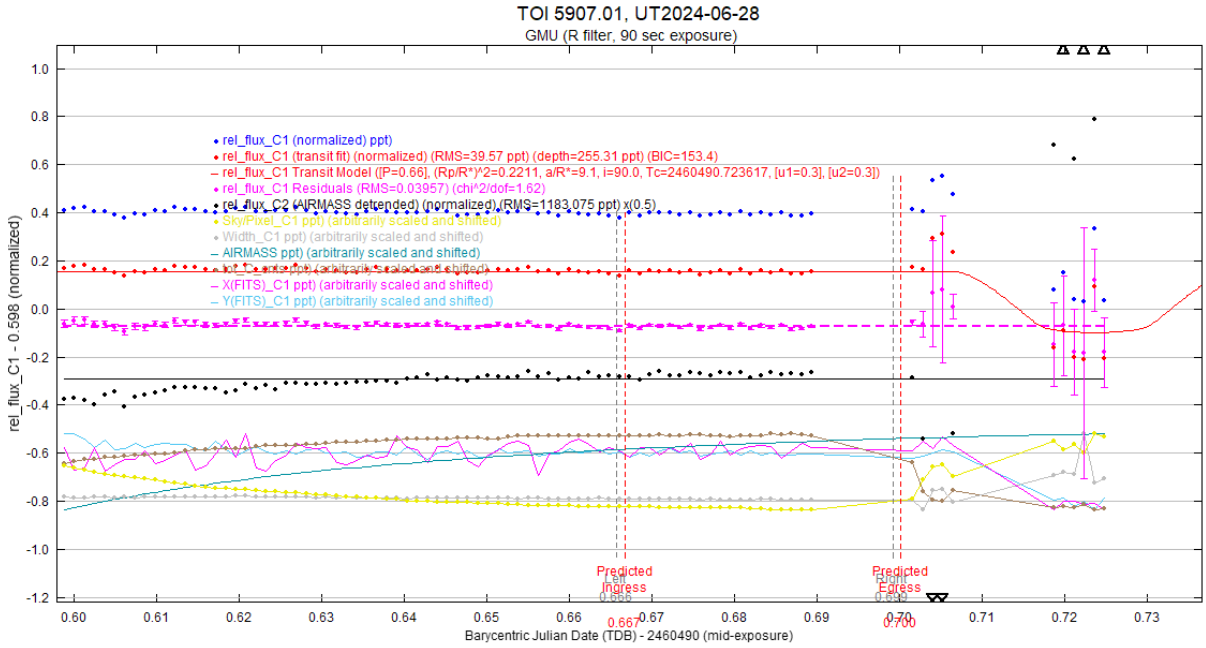

Figure 3. The light curve plot for TOI 5907.01

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.

5.1

We were unable to confirm the planetary nature, since the predicted ingress and egress times were not accurate. The dip in the transit was far outside the predicted ingress and egress. Additionally, the transit depth from the light plot (255.31 ppt) doesn't match up with the predicted transit depth (3740 ppm). The high RMS of 39.57 also points out that there is no certainty for the accuracy of the transit in the light plot, since there is too much scatter.

5.2

There is no other work done for TOI 5907.01. Since our work is inconclusive, we are unable to discover its properties.

Conclusions and Future Work

We wanted to confirm the planetary nature of the TESS object TOI 5907.01 using the ground-based light curve. However, we were unable to do so, given that the transit did not match

the ingress and egress times. The data was inconclusive, so we would need further analysis to make any conclusions.

If we wanted to continue working with TOI 5907.01, we could try and see if the weather was the cause of our results. We would check the cloud coverage and light pollution to see if they had an effect on the outcome. Additionally, we had to remove a significant number of sciences due to streaking and bad-quality images. This could have taken away from and corrupted the data result. Next time, we could make sure that we take clear images with the telescope to hopefully get a better result.

Acknowledgments

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