Ground-based Light Curve Follow-up Validation Observations of TESS Object of Interest TOI 5907.01

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Abstract

The Transiting Exoplanet Survey Satellite (TESS) has been used to gather data for thousands of exoplanets in orbit and their host stars. The goal of this study is to confirm the existence of TESS Object of Interest (TOI) 5907.01 through ground-based light curve follow-up observations. Utilizing observational data provided by George Mason University, we were able to plate-solve images and generate the light curve for TOI 5907.01. After analysis of the light curve generated by AstroImageJ, the results regarding the presence of a transit were inconclusive. Future work needs to be done to definitively confirm or refute the existence of a transit for TOI 5907.01.

1. Introduction

To date, over 5,000 exoplanets have been discovered out of the billions in our galaxy (1). The TESS mission launched on April 18, 2018, with the goal of capturing the sky over the course of two years. TESS is now an extended mission, with its prime mission concluding in 2020 (2).

A validation procedure is taken to identify the most promising candidates out of the TESS data, which saves observational time and resources. (3) The challenge is to find exoplanets among these candidates. These candidates were collected and sent back to ground-based research where observatories verify the existence of transits. George Mason University collected the data for research on TOI 5907.01.

In this paper, we present follow-up observations of TOI 5907.01. TOI 5907.01 has a stellar radius of 1.08017 and a solar effective temperature (Teff) of 5766 kelvins. TOI 5907.01 also has an orbital period of 0.6583175±0.0000797 days. The goal of this

paper is to investigate whether or not TOI 5907.01 has a transit by determining whether or not the transit occurs on the expected star at the expected time, with the expected duration 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.

2. Observations

In Section 2.1 we present the TESS Object of Interest 5907.01 and its exoplanet candidate properties, its host star properties from the Tess Input Catalog, the *Gaia* mission, and the other archival sources. In Section 2.2 we present the TESS sector light curve. In Section 2.3, we present a summary of the observational data collected with the George Mason University 0.8m telescope.

2.1 Exoplanet Candidate Properties

TOI 5907.01 has a radius of 8.31454± 2.06084 R_Earth and an Insolation (Earth Flux) of 2467.92. The transit depth (mmag) is 4.068266±2.583051 and its predicted transit duration is 0.796±0.417 hours. It has a stellar effective temperature (K) of 5766±124.466, stellar surface gravity (g) of 4.38392±0.0776029, and a stellar density (g/cm^3) of 1.152338±0.247946. TIO 5907.01 has a stellar luminosity (L_Sun) of 1.161923±0.0479221.

2.2 TESS Sector Light Curve

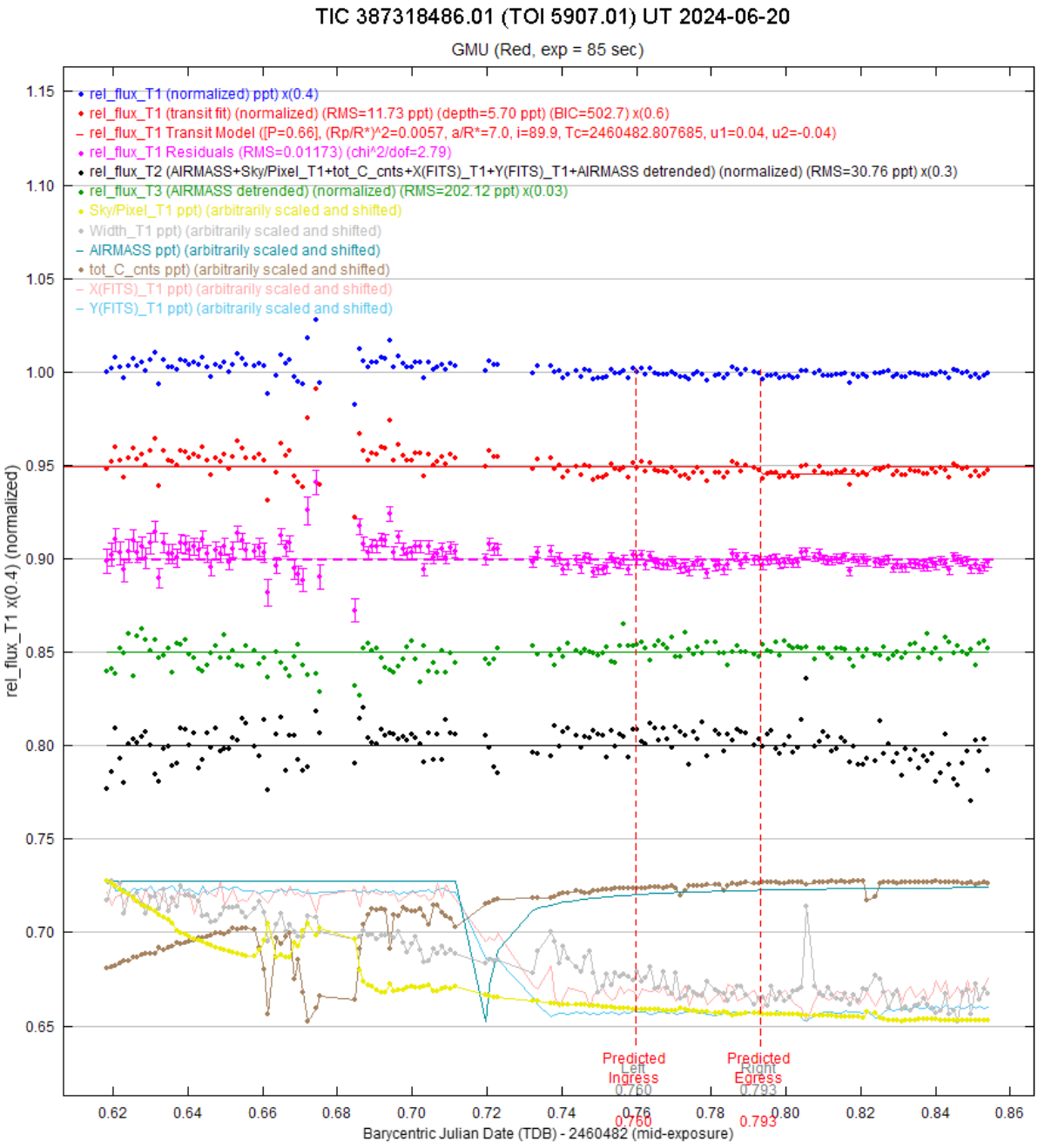

Figure 1. Ground-based Light Curve of TOI 5907.01 (AstroImageJ)

2.3 Observational Data

There were a total of 205 exposures in the beginning. After removing blurry and noisy data, there were only about 185 exposures. The exposure time for these images was 85 seconds and the R-type filter was used. The start time was 02:09 and the end time was 02:57. The date of the observation was Thursday 2024-06-20. The RA and Dec of TOI 5907.01 were 21:00:52.78 and 17:06:59.14 respectively.

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.

3.1 Analysis Tools

AstroImageJ is the main tool we used to both process and produce analysis for TOI 5907.01. We first imported an Image Sequence from AstroImageJ to remove any bad images we may come across and then we used the DP Coordinate Converter and CCD Data Processor to process and plate-solve the data for analysis. We used the Aperture Photometry Tool to help us generate a Seeing Profile for our target. To generate the light curve for TOI 5907.01, we used the MultiPlot Tool which opened the Multi-plot Main, Data Set 2 Fit Settings, Multi-plot Reference Star Settings, and Multi-plot Y-data panels. We also used exofop.ipac.caltech.edu to help plug in parameters for TOI 5907.01.

3.2 Ground-based Light Curve Analysis

Before starting the analysis process, we first looked through each image and removed any blurry or noisy images from the dataset. This will help improve the quality of the light curve in the future. After that, we plate-solved and reduced the images using the CCD Data Processor Tool in AstroImageJ. Using the Aperture Photometry Tool from AstroImageJ, we generated a seeing profile of TOI 5907.01. Next, we created a 2.5' circle around our target and used the Multiple Aperture Tool provided by AstroImageJ to place our apertures. We then dragged and dropped the Gaia stars .radec file into AstroImageJ. After saving the apertures and measurement data, we used the MultiPlot Tool and adjusted the plot data for our light curve accordingly until we reached a clear and desirable result.

4. Results

In Section 4, we present the results we obtained from the data collected and processed by AstroImageJ. We present the ground-based light curve as shown in Figure 1 (see above), the Seeing Profile, as shown in Figure 2, and the Dmag vs. RMS plot as shown in Figure 3.

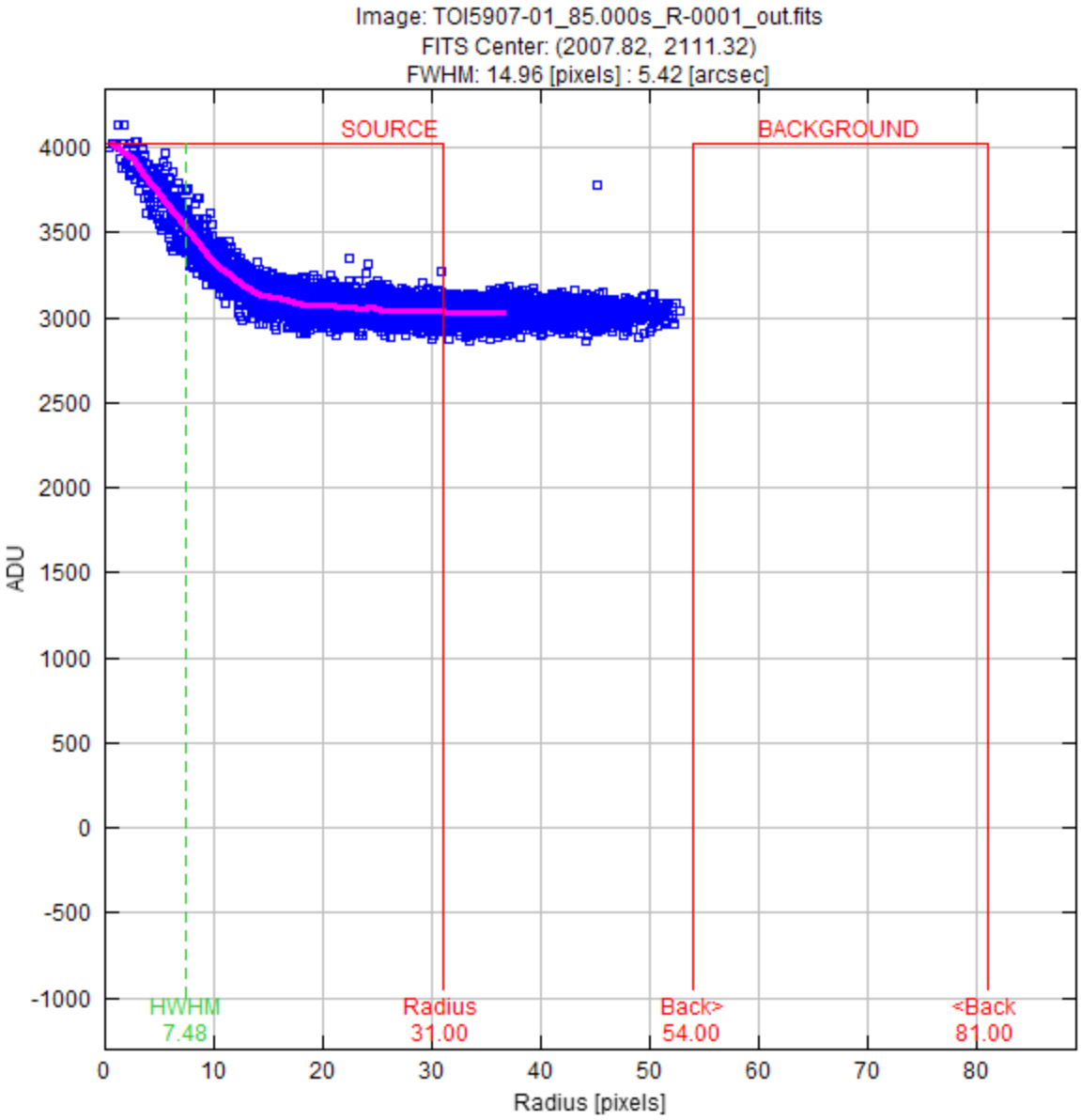

Figure 2. Seeing Profile for TOI 5907.01 (AstroImageJ)

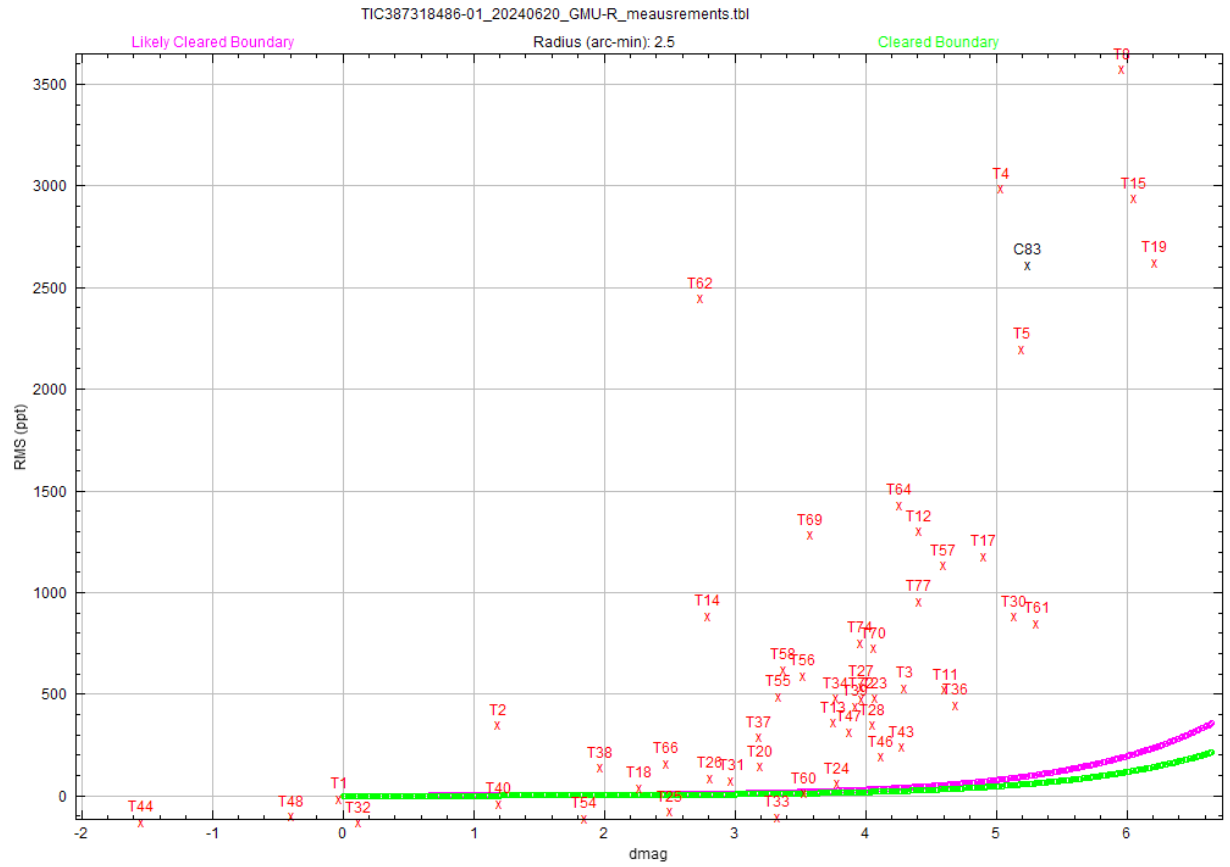

Figure 3. Dmag vs. RMS-plot for TOI 5907.01 (AstroImageJ)

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Possible dispositions of the star being the source of the target predicted depth:
   Likely cleared (NEBdepth/RMS is between 3 and 5)
   Cleared (NEBdepth/RMS is >= 5)
   Cleared-too faint (NEBdepth >= 1000ppt)
   ***Not Cleared-flux too low*** (weighted average of Source-Sky counts per aperture pixel < 2)
   ***Not Cleared*** (none of the above conditions are met)

Summary count of dispositions:
         0 Likely cleared
         0 Cleared
         0 Cleared-too faint
        35 ***Not Cleared-flux too low***
        51 ***Not Cleared***

Image shift statistics:
            stdev.(arc-seconds): 25.7492 in X and 17.0942 in Y
            max. deviation (pixels): 1002.8886 in X and 135.0221 in Y
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Figure 4. NEB analysis, no reference stars cleared the NEB analysis

5. Discussion

The light curve as shown in Figure 1 reveals no transits. There is only a straight line between the predicted ingress and egress, meaning that there are no signs of a transit. Thus, we believe that there are no transits at that predicted time. In addition, none of the reference stars successfully cleared the NEB analysis as shown in Figure 4. Given these factors, it is unlikely that there is a transit for TOI 5907.01.

6. Conclusions and Future Work

The goal of this paper was to confirm the existence of TOI 5907.01 through ground-based light curve observations. We were not able to confirm the planetary nature of TOI 5907.01. We were able to create a ground-based light curve, along with an NEB table and Dmag vs RMS plot. However, the light curve did not reveal any transits and no Gaia reference stars within a 2.5 arcmin radius successfully cleared the NEB analysis.

More work will need to be done to confirm or deny the existence of a transit for TOI 5907.01. We hope better data samples and further light curve analysis could reveal more about TOI 5907.01.

References

1. *Https://Ajcn.Nutrition.Org/Article/S0002-9165(22)0...*, ajcn.nutrition.org/article/S0002-9165(22)00635-9/ppt. Accessed 24 June 2024.
2. Jacewicz, Natalie. “Do Carrots Really Help Your Vision?” *NPR*, NPR, 2 June 2017,

www.npr.org/sections/thesalt/2017/06/02/529142959/do-carrots-really-help-your-vision.

3. Mantovan, Giacomo, et al. “Validation of Tess Exoplanet Candidates Orbiting Solar Analogues in the All-Sky Plato Input Catalogue.” *OUP Academic*, Oxford University Press, 6 Sept. 2022, academic.oup.com/mnras/article/516/3/4432/6692879.