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Validation of TESS object of interest TOI-5886.01 through ground-based light curve follow-up observations

Abstract

TESS's full name is The Transiting Exoplanet Survey Satellite. TESS's mission is to observe stars to find exoplanets. TESS conducts two-year observations of the solar neighborhood and monitors the periodic decrease in brightness of stars caused by transits caused by planets passing by. The goal of TESS is to identify a large number of asteroids. It will identify asteroids and measure their sizes. Through follow-up observations, we can get the masses of some planets. Select a star, use AstroImageJ (AIJ) to generate a light curve, and use NEB check to check whether the star has exoplanets. There are usually transits on the light curve, and the RMS of NEB is too large, which means that the transiting planet is not the planet of the target star we are observing.

Keywords: Transit method, Tess, exoplanet

1. Introduction

NASA has found thousands of exoplanets by observing planetary transits. The Kepler mission was designed to explore the diversity and structure of exoplanetary systems. Its nine-year mission resulted in thousands of confirmed exoplanets and, due to how much data was produced, thousands more in the process of confirmation. The transit of exoplanets is one of the methods currently used by scientists to search for exoplanets. The purpose is to find exoplanets that can support life like Earth. Searching for exoplanets has become an essential field of astronomical research. Despite significant progress, the field still faces ongoing challenges in identifying exoplanet candidates and fully understanding their properties (factors such as distance).

The reason for the existence of this paper is that we need to observe stars and use AstroImageJ (AIJ) to prove or investigate whether the target star has exoplanets among thousands of candidates that need to be validated. We can use this paper to prove the possibility of exoplanets.

Usually, early work will leave some unanswered questions or new questions. The observation tools were blocked then and could not be verified perfectly. This paper can solve the problem when encountering difficulties and improve the subsequent conclusions. There may not have been a paper published on specific TESS target stars before, so this paper cannot be regarded as a conclusion.

In this article, our target star is TOI-5886.01; proposed Follow-up observations revealed that this star has a radius of 11.6 and an orbital period of 0.97(days). We aim to investigate whether the transit occurs to the expected star at the expected time, duration, and depth.

Section 2 presents our observations from TESS and the George Mason University 0.8m telescope. Section 3 presents our analysis of the TESS light curve for TOI-5886.01 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

Section 2.1 presents the TESS Object of Interest TOI-5886.01 and its exoplanet candidate properties, host star properties from the TESS Input Catalog, the Gaia mission, and other archival sources. Section 2.2 presents the TESS sector light curve(s). In Section 2.3, we present a summary of the observational data collected with the George Mason University 0.8m telescope.

2-1 Archival sources

For the observation of TOI-5886.01, I used MAST and Exoplanet Archive to obtain more archives about the target star.

2-2 TESS light curves

TESS produced the light curve of TOI-5886.01. **Figure 1** shows the relative flux versus phase plot of the target. From the light curve alone, the target likely is a true positive. However, observations like ours are necessary for subsequent confirmation of target identity.

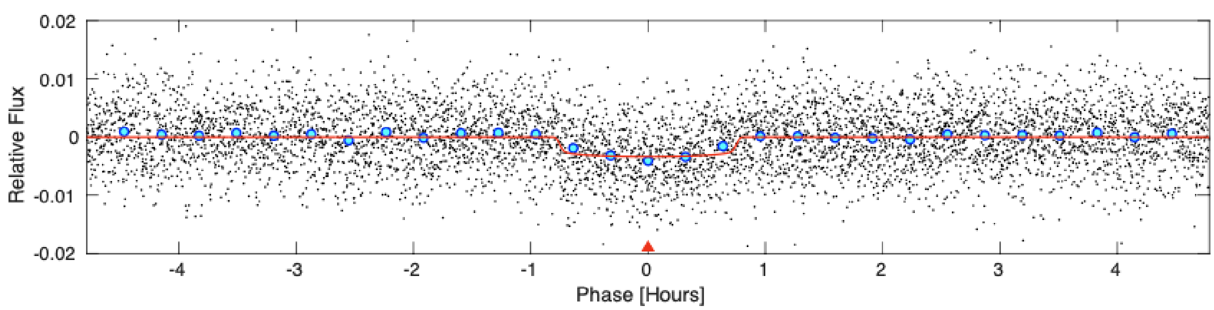

Figure 1. Light curve plot of TOI-5886.01 from the TESS summary report. *Note*. The image was imported from the MAST (Mikulski Archive for Space Telescopes) portal. From Mikulski Archive for Space Telescopes.(n.d). [A list of observations for TIC 15682927]. https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html

2-3 Observational data

We used the George Mason University 0.8m telescope to collect observation data of TOI-5886.01, the number of exposures is 219, the exposure time is 85s, the observation date is June 19, 2024, we use R filter, the RA value is 20:27:57.32, the Dec value is +37:08:46.88, BJD TDB start time and end time is 10481.6575 and 10481.7084, but only the numbers after the decimal point are taken.

3. Analysis

3-1 Analysis tools

AIJ retains the general image processing functions, but AIJ has to be simplified for time series differential photometry, light curve detrending and fitting, light curve drawing, etc., which is especially suitable for applications that require accurate light curves. Enter this data using AIJ to build the correct light curve using the plate resolution image. I am also using Gaia star data to find similar stars around a target star. By comparing our target star to similar stars, we can see if the transit data is reflected in the comparison stars.

3-2 Analyze light curves

We use specific tools like the AIJ's aperture photometry. In **Figure 3**, we can see that the light curve darkens between the Ingress time of 0.657 and the Egress time of 0.708. We can see in **Figure 1** that the change is between 0.00 and -0.01, which means A planet or star passes between the telescope and the target star during this period. It is displayed on the light curve plot as a range between 1.0 and 0.9. This is because it is convenient to compare other data on the plot. The NEB inspection was inconclusive because the unsuitable reference stars were to be canceled. There may still be many inappropriate reference stars, but they may be ignored and not canceled, so there is no guarantee that NEB Check will not cause any errors.

4. Results

The graphs in **Figure 1** and **Figure 3** show that there is indeed a transit of the target star. The decrease and recovery of the target star's brightness over time can be observed in the figure, indicating the occurrence of a transit. However, the NEB inspection in **Figure 4** shows excessive RMS flux, which may have affected the accuracy of the results. Therefore, it is impossible to confirm whether the target star has exoplanets.

5. Discussion

We know that the RMS of the NEB check in **Figure 4** is very high, and most of the stars are scattered and not on a beautiful curve. Although the transit with dimming brightness can be seen in **Figure 1** and **Figure 3**, in **Figure 4**, The RMS of the NEB check is very high, so it is not possible to confirm that this target star has a planet or it is because the telescope cannot distinguish between the shallow inclination of the brighter star (which is characteristic of planetary transits) and the more profound inclination of the dimmer star (which may be signal from an eclipsing binary, a binary star system in which one star passes in front of the other star) resulting in changes in brightness.

6. Conclusions and Future Work

The ultimate goal of field tracking is to achieve a candidate false positive probability of <1%. This is difficult to do with light curves alone. One has to use NASA's Exoplanet Archives, high-contrast imaging to see if there are any faint signs of nearby stars, look through the spectrum to see if there are any binaries in the spectrum and rule out significant radial velocity changes, and from the TESS mission The TESS light curve test itself is used for proof because the RMS checked by

NEB cannot prove that the target star has a planet. After all, the characteristics of the binary star may cause this, and the detailed statistics are wrong. Currently, forward verification analysis is not performed. Some residual errors may have occurred for future work due to equipment limitations in the previous observations. These residual errors may be fixed in future observations to improve the light curve plots. Future light curves will be an essential tool in helping to verify the existence of exoplanets, but we will still need other tools to verify them.

7. Tables and Figures

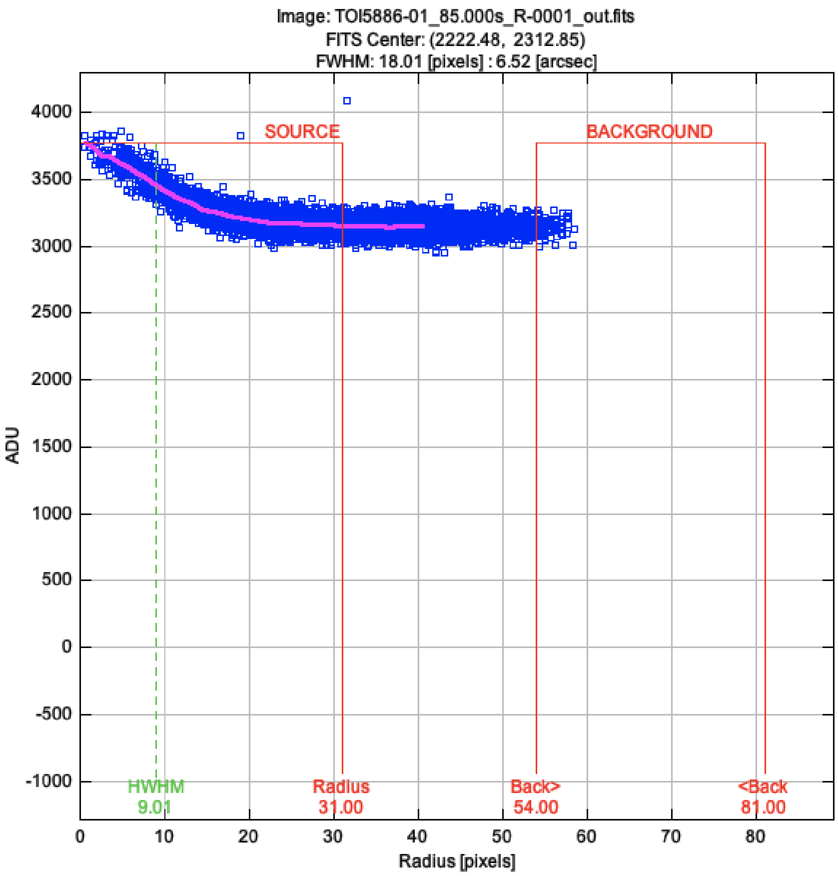

Figure 2. Seeing Profile obtained from Aperture Photometry (AstroimageJ)

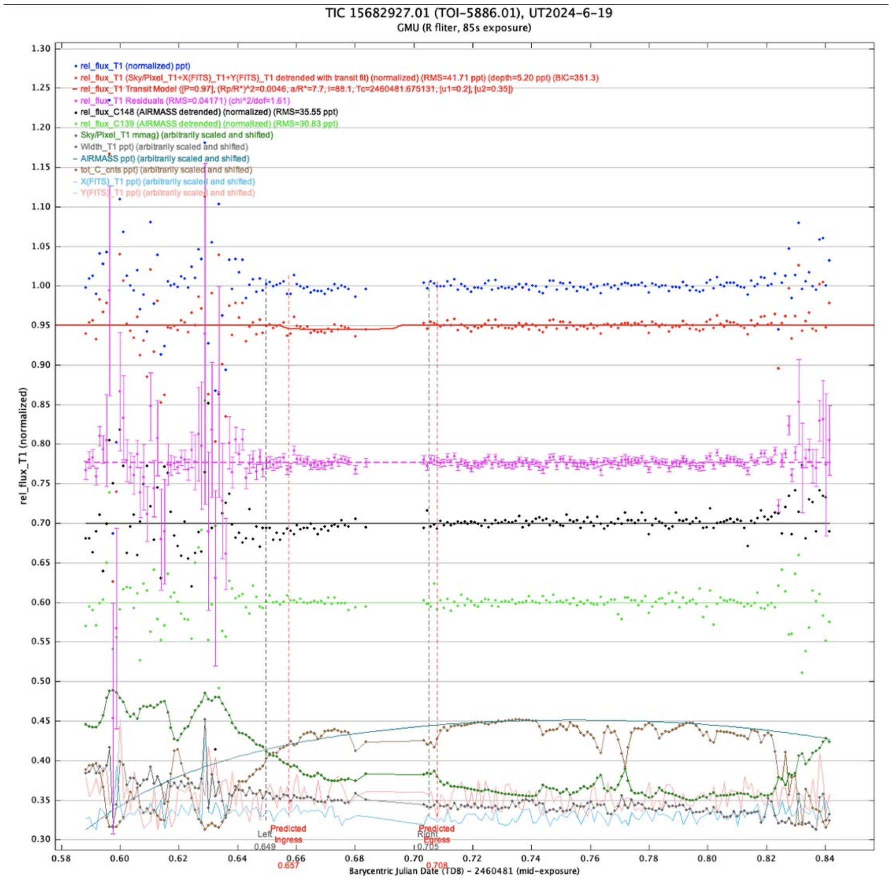

Figure 3. Transit light curve obtained from multi-aperture photometry (AstroImageJ)

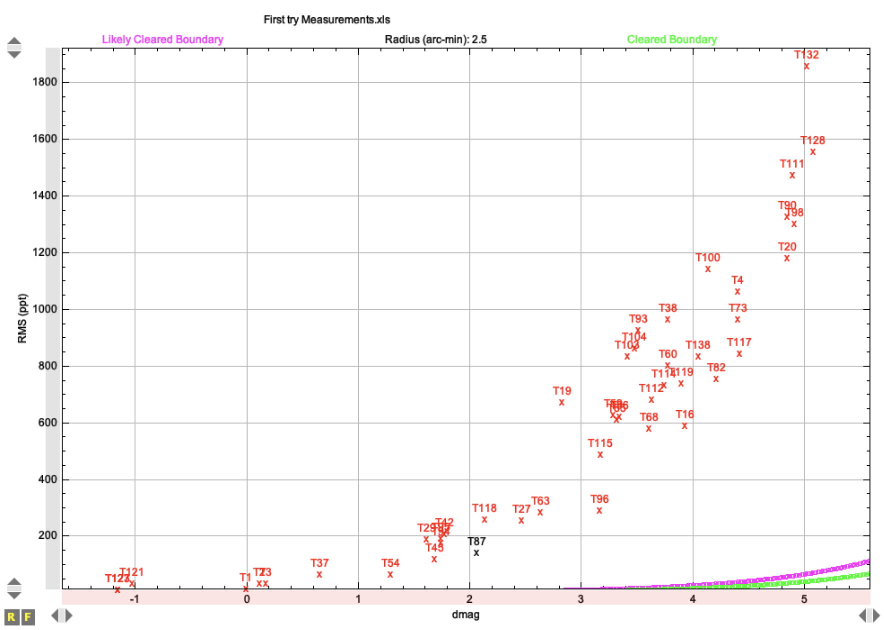

Figure 4. NEB analysis results (AstroImageJ)

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