Ground-based Light Curve Follow-up Validation Observations of TESS Object of Interest TOI 5868.01

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Abstract

This study aimed to provide additional confirmation, details, and classification for TESS Object of Interest (TOI) 5868.01. After obtaining the observation data of TOI 5868.01 from George Mason University, we could generate a stellar light curve of this object using AstroImageJ. Upon producing this light curve, it is unclear if a transit is present. The data had an initial scatter percentage (RMS) of 2.263%. We discovered that by using detrending parameters like AIRMASS and Width_T1, the RMS dropped to 1.976%. This is still not perfect though. As a result, while suggestive, the study's results are not definitive. They suggest that the start might have had a transit, however due to the noise in the data, further analysis is recommended. There does seem to be some activity in between the ingress and egress, but the graph only starts to fluctuate or dip much after the predicted ingress has started. Though a definitive conclusion cannot be made just yet, additional information needs to be gathered and compared with the available data to validate TOI 5868.01 as a transit.

Introduction

Following the discovery of the first exoplanets in the 1990s, curiosity about discovering more increased rapidly. The initial few could only be observed with simple ground-based telescopes, similar to those used to observe planets within our solar system (4). By contrast, telescopes are now often located in space. One such telescope is TESS, NASA's Transiting Exoplanet Survey Satellite.

On April 18, 2018, TESS was launched on a two-year mission to catalog the entire sky. In order to look for transits, more than 200,000 bright stars were studied. Stars that may undergo transits are reported back to the TESS mission's ground-based component. Different observatories conduct additional analyses on the TESS Objects of Interest (TOIs) to ascertain the compositions of the confirmed exoplanets and to confirm or refute the existence of a transit (3). The George Mason University Observatory provided the data for this research.

For this study, the TOI that was observed was TOI 5868.01. The object's declination is +34d21m05.93s, and its right ascension is 20h53m40.69s (2). The estimated mass of TOI 5868.01 is 1.49 M_Earth. It is 14.0246 R_Earth in radius. It was reported to TESS on June 6, 2024, and hasn't been updated since. An approximate time of 6 hours and 44 minutes was estimated for the transit. Give or take 17 minutes, the actual transit time was 2 hours and 53 minutes. The actual time the light began to exhibit fluctuations or "dips" differed greatly from the "predicted" time of transit (1). The George Mason University Observatory is where the data was gathered. There was a lot of streaking and smearing for the stars in many sciences. The study was faulty as a result of this problem and additional noise that occurred during the data collection. To get a more reliable conclusion, more information needs to be gathered and examined.

Methods

The George Mason University Observatory recorded TOI 5868.01. The surrounding light pollution, which was primarily blue, was blocked out using a red filter. A 65-second exposure time was used for the sciences. The transit's anticipated arrival and departure times were 22:50 and 1:43, respectively.

To visualize the scientific data collected at George Mason University's observatory, we employed AstroImageJ. After looking at these photos, we discovered that about half of them could not be used because the target was streaked across the sciences, out of focus, or not clearly visible in the frame. After that, the remaining data was reduced and aligned to create a light curve that would aid in seeing potential dips in light. We had to filter out the sciences which had scattered and streaks of light to clear the data and ensure a light curve with lower RMS.

We manually spaced and normalized the various data sets using AstroImageJ so that each could be used separately. When it came to reference stars, the already high RMS percentage was further increased by adding more reference stars, so it was better to just use C224 and C240. For detrending the data we employed parameters WIDTH_T1 and AIRMASS. The others had little to no impact on the RMS percentage, or they raised it. The data remained inconclusive and the RMS value remained high following these plot modification adjustments. A significant contributing factor in this was the uncertainty surrounding the TESS observation of TOI 5868.01's transit time. As shown in Figure 1, this resulted in the predicted transit not clearly falling within the data collection range. Our data contained so much noise that it was challenging to identify specific features, such as the NEBs, or to distinguish between fluctuation and dips in light intensity that were affecting the data. Detrending, however, reduced the RMS and only caused fluctuation at the location where we think the transit may have occurred.

Results

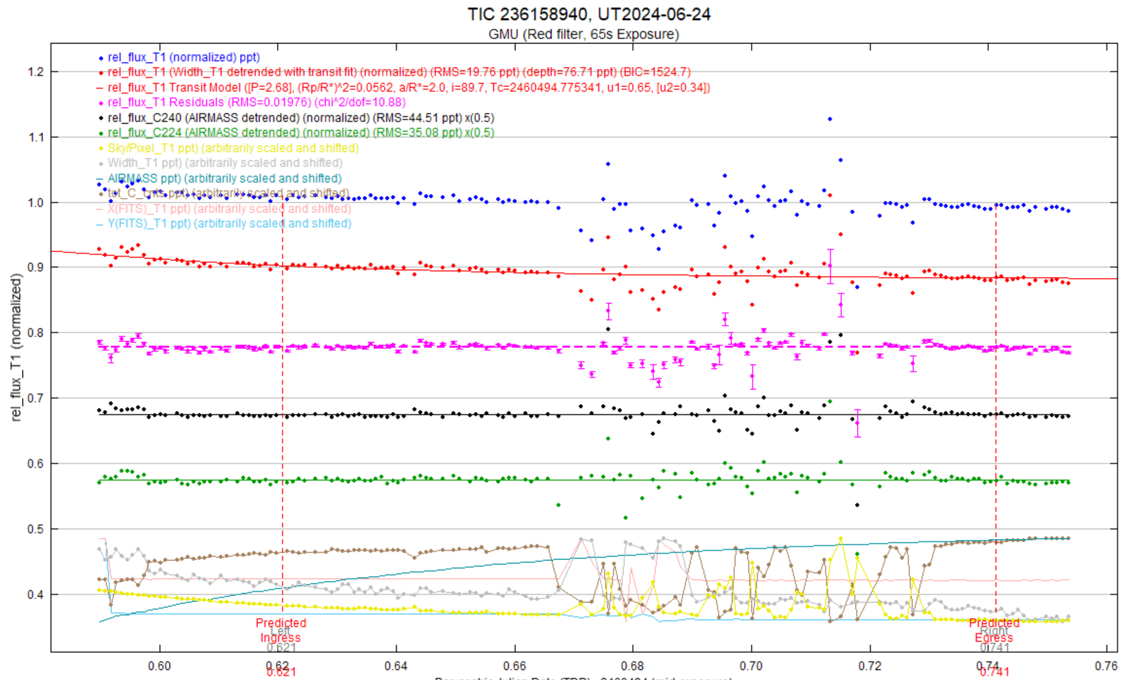

Fig. 1

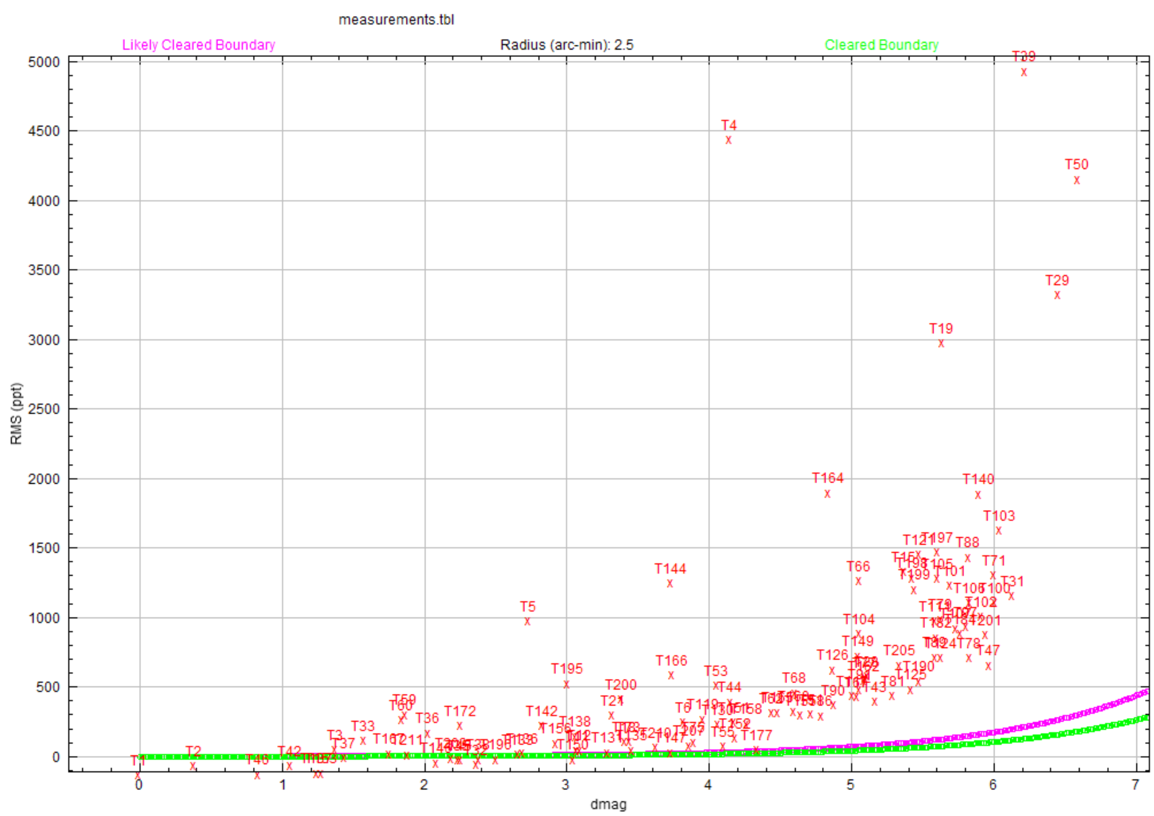

Fig. 2

Because of data noise and streaking, our results were not entirely conclusive. The predicted ingress and egress times of the transit do not accurately reflect when there appears to be movement in the amount of light, as can be seen in Figure 1. As the tot_C_cnts points (represented in brown) interact with the Y-FITS_T1 curve (represented in teal), which depicts the Earth's atmosphere curve, Figure 1 also illustrates the target's visibility. The points in an ideal data set would roughly match the curve, but our observation shows that this is not the case. As can be seen in Figure 1, the tot_C_cnts points exhibit frequent fluctuations that indicate the degree of data skewing.

In Figure 2 we can highlight another example of lack of precision in our data. An NEB check is necessary to see if the dips in light are actually due to planetary transits or if they are a factor of a fainter star with a larger dip (which is a characteristic of an eclipsing binary). To ensure that the stars around are not NEBs they must be located at or below the curve in Figure 2. This was not the case. However, it does not indicate that all of the stars in the vicinity were NEBs but rather that this data is not very precise.

Discussion

Though many different techniques were able to lower the total RMS percentage, the predicted ingress and egress times were very off leading it to be difficult to properly identify a transit. Additionally, there is not a clear dip at any point in the graph. It seems that the star remained at the same amount of light throughout the data and the place where there is fluctuation could just be noise in the sciences.

Further research would still be required even if we were able to detect the transit in our distorted data. It's important to reexamine the original sciences and identify any that might further skew the data. A second look at the original sciences that were removed is also warranted, particularly the ones that surround the point where we might have discovered a transit. Without a doubt, TOI 5868.01 should be looked into further due to the slight indication of a transit.

Conclusion

In conclusion, the problems in the sciences prevented us from reaching a precise conclusion. But it's possible that we happened to catch the transit at a different time of its expected entry and exit. Given the extreme uncertainty surrounding the transit prediction, this is not totally implausible. There should be more time, consideration, and research put into TOI 5868.01. By gathering data under more favorable conditions, we would be able to confirm, characterize, and categorize this target.

References

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