Ground-Based Light Curve Follow-Up Validation Observations of TESS Object of Interest TOI 5191.01

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Abstract

The goal of this observation was to confirm the presence of an exoplanet around TESS object of interest 5191.01. The NASA TESS mission first observed this stars potential exoplanet. Using the light curve method, the authors observed the star during the expected exoplanet transit. Unfortunately, the authors results were inconclusive due to data loss during the transit. Cloud cover caused the loss of data of the first half of the transit including the expected ingress of the exoplanet. This loss of data means the authors cannot say whether or not there is an exoplanet around TOI 5191.01 but preliminary data suggests there is potentially exoplanet around star TOI 5191.01, but more data will need to be collected because key data was lost due to cloud cover during the transit.

Introduction

Long thought to exist, the first exosolar planet (exoplanet) was discovered in 1992 (*Exoplanets - NASA Science*, n.d.). Since that time, due to improvements, in space-based and ground-based telescopes and computer models, over five thousand exoplanets have since been discovered (*NASA Exoplanet Archive*, n.d.).

There are several techniques used to identify and confirm the existence of an exoplanet the most common techniques are the Radial Velocity method which observes variations in a star's motion and the Transit method which is a direct observation of the exoplanet obscuring the light from the primary star. Each of these techniques has advantages and disadvantages, therefore absolute conformation requires observations using both techniques. For example, with the transit method you can learn what is in the atmosphere of the exoplanet but you can only see exoplanets that eclipse their host star in line with earth while the radial velocity method can be used on any star (Wright & Gaudi, 2013).

TESS (Transiting exoplanet survey satellite) is a NASA mission launched in April 2018 with the goal of finding exoplanets. The TESS mission scanned the sky creating list of 7,000 stars with possible exoplanets that need to be verified (Ricker, 2021). The authors decided to observe one of these stars. TOI (Tess Object of Interest) 5191.01 was marked for follow up by the Tess mission as a candidate for an exoplanet. The authors goals in this study were to confirm this exoplanet, to do this the authors used the light curve method to verify the existence of the exoplanet. The authors observed the transit using the ground based 32" telescope at George Mason University.

In section 2, The authors present our observations from the George Mason's 32" telescope. In section 3 the authors present their analysis of the TESS light curve for TOI 5191.01 and their ground based light curve analysis. In section 4 the authors present their light curve results. In section 5, the authors discuss their results. And in section 6 the authors present their conclusions and future work.

Observations

In Section 2, the authors present the TESS Object of Interest 5191.01 and its exoplanet candidate properties, its host star properties from the TESS Input Catalog, the Gaia mission, and other archival sources. The authors also present a summary of the observational data collected with the 32" telescope at George Mason University.

During the observation, the authors took 179 exposures using the infrared filter. Each exposure was taken with a ninety second exposure time. The authors took exposures from Julian dates 60489.59818182886 to 60489.85352951381. The star is located at 291.568 RA 18.9953 DC. The exoplanet would have an orbital period of 3.01 days, A depth of 6.7 and planetary radius of 15.5.

Analysis

In Section 3, the authors present their analysis of the ground-based light curve using AstroImageJ. The authors used AstroImageJ to create master dark files and flat files and then the authors subtracted these master files from their science to reduce interference from external factors such as dust and debris on the lens. After this the authors manually reviewed each image looking for satellite streaking and cloud cover (cloud cover obscured data from 0.65-0.72 examples of data with and without cloud cover can be seen in **figures 3 and 4**). Then the authors plate solved their images to determine their exact location in the sky. After that, the authors placed apertures on the host star as well as comparison stars to collect data from the host star as well as use data from comparison stars to further reduce interference. The authors then made measurements from the data and then plotted these measurements in AstroImageJ To create a sub composite summary graph with a light curve seen **Figure 1**. They then preformed a NEB (nearby eclipsing binary) check to determine if a nearby eclipsing binary was causing a false positive. This test came back inconclusive as no stars were below the cleared or likely cleared lines. The NEB check can be seen in **figure 2**.

Results

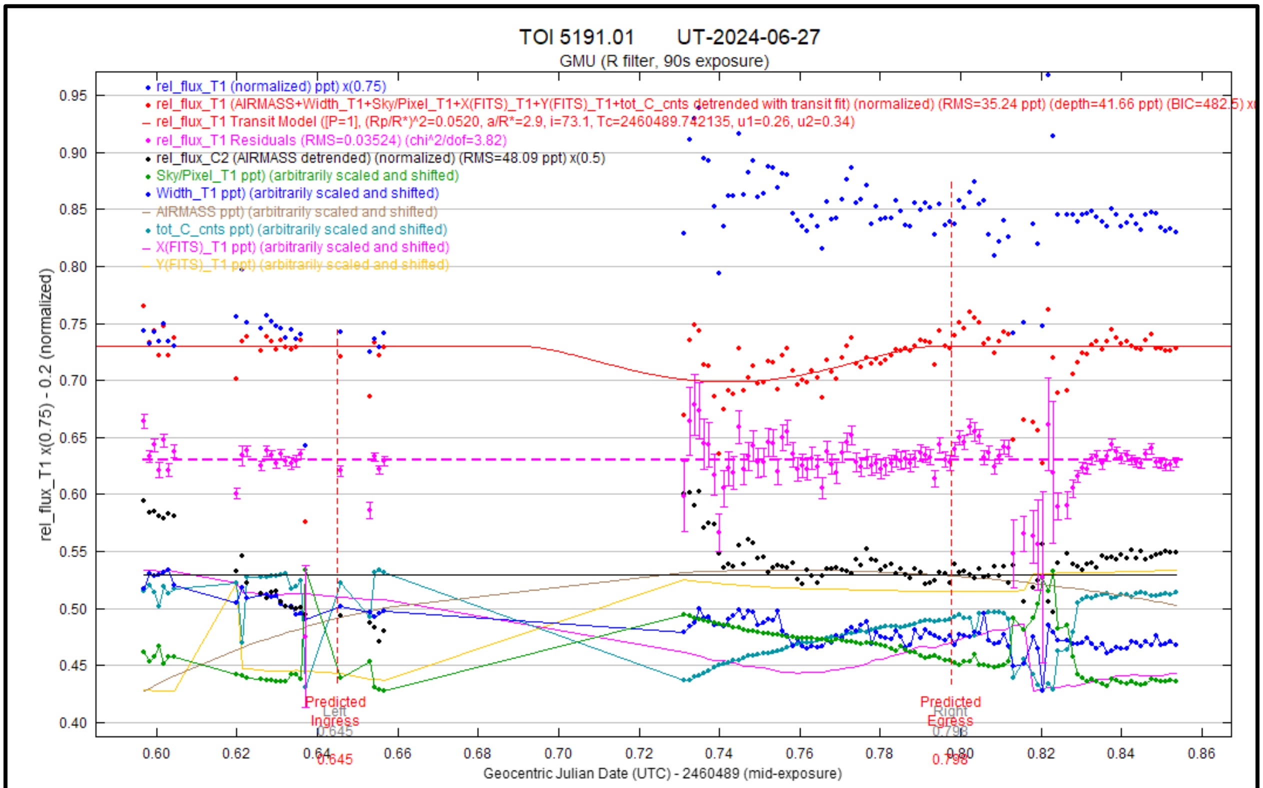


Figure 1(above): Sub composite summary graph of observed data from TOI 5191.01

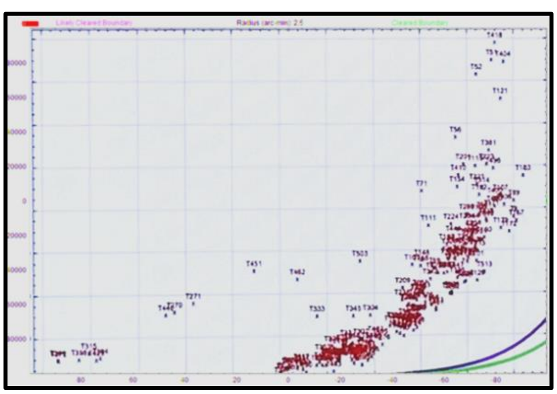
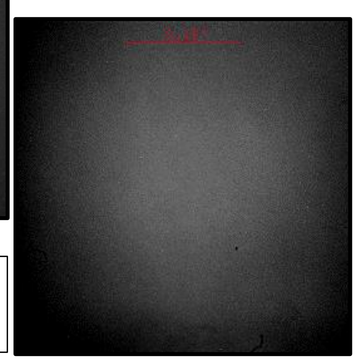


Figure 2(above): DMAG-RMS plot

Figure 3(above): image without cloud cover

Figure 4(below): image with cloud cover



Note: Data was lost from 0.66-0.73 due to cloud cover seen in **figure 4.**

Discussion

Out of the 179 exposures taken only 124 were usable due to cloud cover, unfortunately, most of these exposures were taken during the first half of the transit including the expected ingress. It was not possible for the authors to make a conclusion because of the loss of data over a crucial time period made their study inconclusive. Nonetheless in **Figure 1** there appears to be a decrease in light brightness during the expected time of transit that appears to potentially be a transit even if the depth of the transit is not what was expected (expected depth 6.7 observed depth was 41.66), however it is impossible for the authors to say if there is an exoplanet there as the RMS is extremely high and there is a loss of data over the first half of transit leading to an inconclusive result as well as the depth being far greater than expected.

Conclusion

The authors could not confirm whether or not there is an exoplanet orbiting TOI 5191.01 because of the loss of data due to cloud cover and a high RMS. However remaining data potentially indicates exoplanet around the star seeing as a transit was fitted that meets expectations for our star. However, this star will need to be further examined to prove the exoplanet because of the loss of data, as well as confirm that it is not a NEB producing a false positive.

References

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