Ground-based light curve follow-up validation observations of TESS object of interest TOI 3877.01

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Abstract

Context

Exoplanets have been a fairly recent topic of interest in the field of astronomy, only having been discovered for a few decades. However, despite the youth of their discovery, they've been a crucial part of astronomical studies; especially those orbiting their parent star in the "Goldilocks Zone". These Earth-like planets could potentially serve as future homes for humanity, which is why they're a huge topic of interest.

Aims

The goal of this investigation is to study data regarding the star Tess Object of Interest (TOI) 3877 to confirm suspicions that it is an exoplanet transiting in front of its star that is responsible for the dimming of its light levels.

Methods

The app AstroImageJ will be used to study and interpret the data of TOI_3877 by taking multiple images captured during the night of observation, sorting them based on shutter settings and exposure length, aligning them, and finally by cutting out outside noise to gather the light levels taken over the period of exposure and making a light curve graph.

Results

Unfortunately, the data I worked with did not align with the predicted times of the transit, so the light curve that I generated served little use for the purpose of the investigation. Because all of the graphed data lied beyond the egress time, there was no way of telling whether or not there was a transit caused by an exoplanet. TOI_3877 will have to be further analyzed for more conclusive results to be reached.

Introduction

TESS Missions

Transiting Exoplanet Survey Satellite, or TESS, is a NASA mission to locate exoplanets orbiting around many stars (Fausnaugh et al., 2021). This is accomplished by observing the target star for many days in a row and seeing if there are any signs of an exoplanet. The most common way that these are detected is by detecting the effect that the planet has on the star via techniques like the transit method (Wang, 2023). When the planet passes into the plane formed by Earth and the target star, it eclipses its star, causing a drop in the observed brightness level visible on Earth. The brightness can then be recorded over a long period of time and analyzed to see if the drop is due to an exoplanet, or if it's in fact a false positive like an eclipsing binary.

Justification

There exist exoplanets that could harbor life and could even contain water (Wang, 2023). As of writing this, there are 60 such Earth-like planets that could potentially serve as future homes for humanity and even possibly contain other forms of life. Studying these exoplanets and their atmospheres will provide more insight into how life could possibly survive in other environments. Several candidates for exoplanets have been identified, but there are still many that need to be studied (Guerrero et al., 2021). One such target is TOI_3877, with possible exoplanet TOI_3877.01. There has not been very much research regarding this such object, and it is important that more research is conducted to see whether there is indeed a transiting exoplanet responsible for the drop in TOI_3877's light levels.

Objective

In this paper, we present follow-up observations of TOI_3877. The suspected planet has a radius of 12.0574±0.97052 Earth radii and an orbital period of 4.1225477±0.0006274 Earth days (ExoFOP 2023). Given the size and small orbital period around its star, it is very likely

TOI_3877.01 is a hot Jupiter. Our goal is to investigate whether or not the transit of this object of interest follows the timing and depth of that of a hot Jupiter and to confirm or deny the hypothesis that it is an exoplanet.

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_3877.01 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 properties of both TOI_3877 and its exoplanet candidate TOI_3877.01 using data from the TESS Input Catalog and other archival sources. In Section 2.2, we present a summary of TOI_3877's observational data collected with the George Mason University 0.8m telescope. In Section 2.3 we present the sector light curve of TOI_3877.

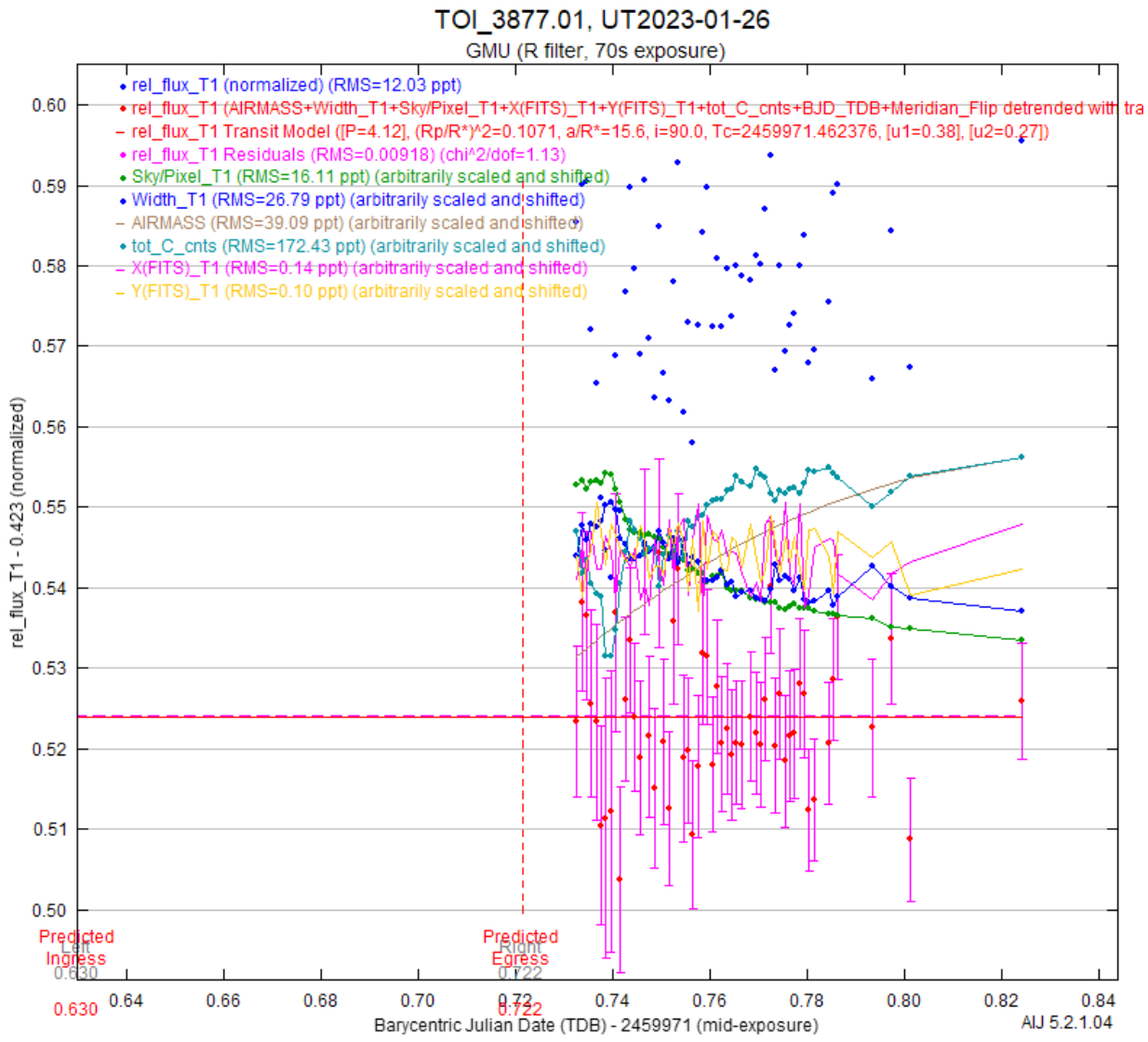
2.1

As mentioned earlier, TOI_3877.01 has a radius approximately 12 times that of Earth's, and orbits around its host star in just 4 days (ExoFOP 2023). It takes just 2 hours for it to transit the star, and it transits with a depth of about 5760 ppm. The star has a right ascension of 11h21m49.07s and a declination of +33d59m28.98s.

2.2

A total of 63 exposures were collected: 5 flats, 2 darks, and 56 sciences, and the exposure time was 70 seconds. They were taken on January 26 and 27 of 2023 from 21:20 to 6:20, with a predicted ingress at 3:07 and a predicted egress at 5:19. An R-type filter was used.

2.3



Light curve for TOI_3877.01

Analysis & Results

As shown in the light curve above, unfortunately, there is not much to analyze because the graph is completely outside of the predicted ingress and egress times. From the available graph, it can be seen that that level of light flux varies greatly, and given the high values of the error bars, it can be inferred that the data is inconclusive. It is unknown whether or not a transit did occur between the ingress and egress times, and it's even harder to predict if it did as the light

curve after the predicted transit is too variable and unstable, showing no signs that a transit did occur beforehand.

Discussion

In section 5.1 we discuss our interpretation of the results and the inconclusive data. In section 5.2 we discuss the relevance of these results in the context of the NASA TESS missions and future research.

5.1

Because the timing was completely off, it is possible that TOI_3877.01 may not be an exoplanet. It is possible that it is an eclipsing binary. According to the Simbad database, there was a galaxy cluster and a radio source found within 2 arcminutes of TOI_3877.01, so it's definitely possible that those other sources caused some interference on the ground.

5.2

As discussed earlier, it is possible that TOI_3877.01 is not an exoplanet, but if it is, it's likely a hot Jupiter due to the orbital period and radius.

Conclusions and Future Work

Due to the gap of data missing, there will be a need for further research regarding TOI_3877.01. It is still unclear if the transit happened during its predicted time, so more observations will need to be made.

References

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