Photometry of Planetary Candidate TYC 3985-1894-1

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Introduction

The star TYC 3985-1894-1 was designated as a planetary candidate during sky surveys completed by the Transiting Exoplanet Survey Satellite (TESS). After being identified as a TESS Object of Interest (TOI), the star must complete a five-step verification process through the TESS Follow-Up Operations Program (TFOP) to either confirm the existence of an exoplanet, or determine it to be a false positive. The first step of the TFOP is ground-based, seeing-limited photometry, which helps to identify false positives created by eclipsing binaries, while also being able to measure transit timing to produce more accurate light curves.

Observations

To collect the data needed to perform seeing-limited photometry, images of the TOI must be captured during the transit. Observations were completed on October 6, 2020 at the Waffelow Creek Observatory located in Nacogdoches, Texas. Throughout this duration, 374 images were taken by an SBIG STXL-6303E CCD Camera mounted on a 0.36m Ritchey Chretien Telescope, which was able to observe the entire length of the transit. These images were then calibrated through the use of an astro-imaging software to begin the photometry process.

Figure 1. GSO 0.36m RC with SBIG STXL-6303E CCD

Figure 2. DSO 0.43m Modified Dall-Kirkham

Additional images were also captured using the Skynet Robotic Telescope Network. The star field shown in Figure 3 was taken on November 7, 2020 at the Dark Sky Observatory in Purlear, North Carolina, by a 0.43m Modified Dall-Kirkham Telescope (shown in Figure 2)

Analysis

After calibration, the images of TYC 3985-1894-1 were analyzed using AstroImageJ (AIJ). Once the calibrated images were loaded into the software, multi-aperture photometry was then performed to examine the TOI in relation to several nearby comparison stars of similar magnitude. Figure 3 illustrates this process, with the green aperture rings encircling the target star, TYC 3985-1894-1, and the red aperture rings encircling the comparison stars. By comparing the planetary candidate to individual, non-host stars, a light curve can be constructed for the TOI by plotting the Normalized Relative Flux versus the Barycentric Julian Date (Figure 5). In this plot, it's expected to initially see horizontally consistent data that transitions to a slight decline before returning to the same stable level as before. The depression that is seen in the data is representative of a magnitude drop as the exoplanet transits its host star. See Figure 4 below for a complete illustration showing how transiting exoplanets produce these light curves.

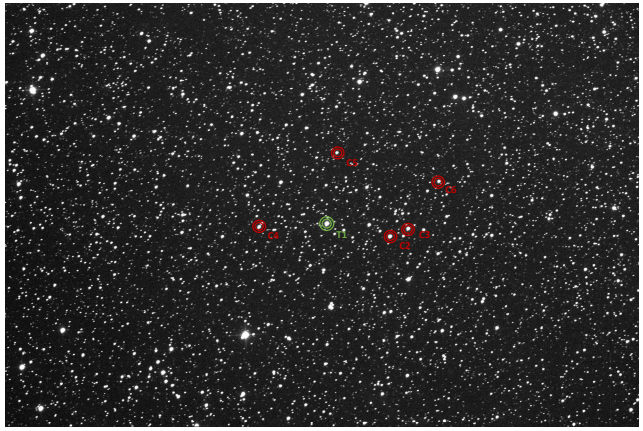

Figure 3. TYC 3985-1894-1 and Comparison Stars

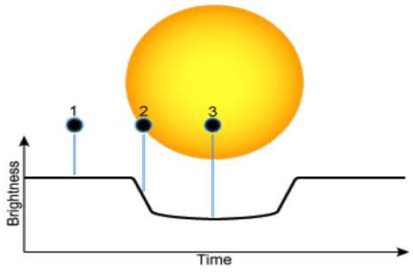

Figure 4. Light Curve of a Star During Planetary Transit

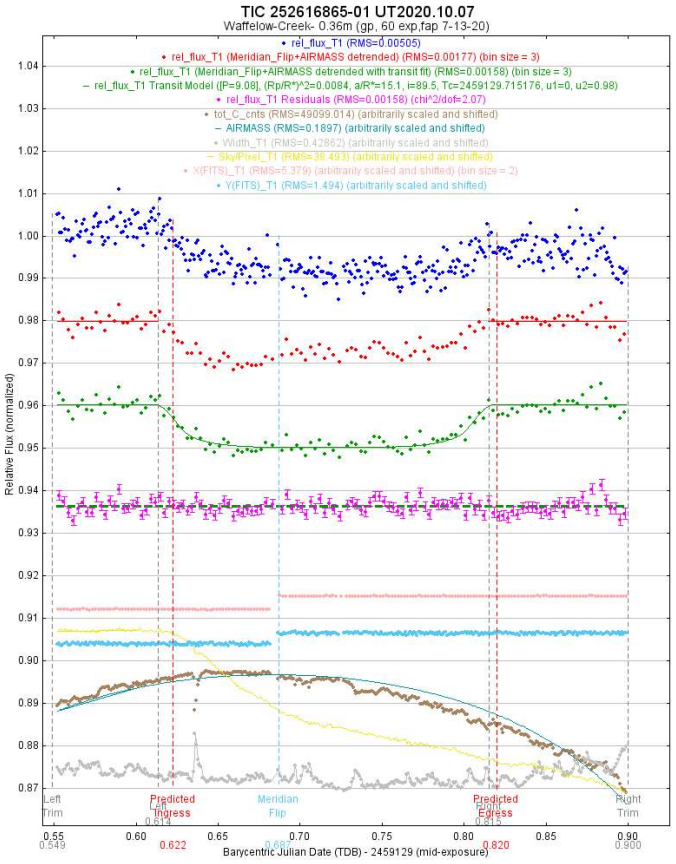

Figure 5. Plot of Normalized Relative Flux versus Barycentric Julian Date

Conclusions

Modeling generated from the image data processed in AIJ estimates that the exoplanet's size is approximately 1.55 Jupiter radii, with an orbital period of 5.71 days, and a transit duration of 0.208 days, or approximately 5 hours.

The data collected from this seeing-limited photometry process can then be used to supplement the future verification steps needed to indubitably confirm the presence of an exoplanet orbiting TYC 3985-1894-1.

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2. Dark Sky Observatory (https://dso.appstate.edu/)
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4. ExoFOP (https://exofop.ipac.caltech.edu/tess/target.php?id=252616865)
5. AstroImageJ (https://www.astro.louisville.edu/software/astroimagej/)
6. Light Curve Illustration (https://www.hao.ucar.edu)

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