Ground-based light curve follow-up validation observations of TESS object of interest TOI 3737.01

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Abstract:
Context: The study focuses on TESS Object of Interest (TOI) follow-ups, by light curve analysis of data taken by ground based observatories. TESS has provided a wealth of photometric data, but ground-based observations are essential to refine parameters and confirm planetary candidates.

Aims: Our primary goal is to enhance the understanding of a TOI by conducting a meticulous ground-based follow-up. Through precise light curve analysis, we aim to confirm the planetary nature of TOI and refine its orbital parameters, ultimately contributing to the characterization of a possible exoplanet.

Methods: We collected high-quality ground-based photometric data using observatory telescopes and instruments. By reducing and analyzing these data, we carried out a light curve analysis to validate TOI's planetary status.

Results:

Introduction:

There are thousands of TOI that have been validated, but also thousands more candidates that have yet to be validated(exoplanetarchive.ipac.caltech.edu). Each of these candidates contain a possible exoplanet, but have not yet been identified or validated. There are many other similar papers, which have a similar context but each one is performed for the possibility of new findings.

The need for validating TOI could also be to answer previously unanswered questions or propose new questions. Previous papers might not have current technological capabilities and so we are now currently able to have different findings and answer previous questions. Previous papers may have a future work section which we are capable of answering now.

In this paper, we present follow-up observations of TOI 3737.01, with a radius of about 15.29 Earths and an orbital period of 5.56 days. Our goal is to investigate whether or not the transit occurs on the star of this TESS object of interest at the expected time, with the expected duration and depth. It is to verify that the transit occurs on this TESS object of interest.

In section 1, the context, we will be introducing the background, need for this paper, the paper in context of previously written papers, and a few basic observations. In Section 2, we embark on a comprehensive exploration of our Observations, drawing from both the TESS mission and the data collected through the George Mason University 0.8m telescope. Moving forward to Section 3, we delve into a meticulous analysis, examining not only the TESS light

curve for TOI 3737.01 but also conducting a rigorous assessment of our ground-based light curve data. In Section 4, we unfold our findings derived from the light curve analysis. In Section 5, we engage in an in-depth discussion of these results. Finally, in Section 6, we bring our work to a close by presenting our well-considered conclusions and outlining the avenues for future research.

In Section 2.1 we present the TESS Object of Interest 3737.01 and its exoplanet candidate properties, its host star properties from the TESS Input Catalog, the Gaia mission, and other archival sources. In Section 2.2 we discuss 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.

TESS Object of Interest 3737.01 exoplanet candidate properties were found on NASA Exoplanet Archive. For this research, the Gaia sources were not used as part of the data.

TESS sector light curves were not given as part of the data to use, and so were not used as observations included in our analysis.

The only parts of data we really took were from the observatory telescope. We collected 127 exposures of TOI 3737.01, at 70.0 second per exposure, from UTC time 21:55 to 9:10. Exposures were collected on 2020 December 20th using an R filter. RA is 04:49:42.52, Dec is +35:18:05.97.

In Section 3.1 we present our tools used to analyze the TESS sector light curve(s) curves using AstroImageJ. In Section 3.2, we present our analysis of the ground-based light curve using AstroImageJ. The main steps we took to analyze the ground based light curves were AIJ Data-Reduction, Plate-Solving with Astrometry.net, AIJ Light Curve Extraction, and Interpreting Light Curves.

From the original dataset of exposures, we had to data-reduce images. To do this, we first hand remove any defect images that are blocked, blurred, or jumped, leading to an unclear view of the target. After this, we proceed to use AIJ's data processing, at which point we fill in the necessary information of the target and observatory into the "DP coordinate converter". Then to use the data processor, we sort the taken exposures into dark, flats, and sciences. We then create a master flat by inputting the flats and darks in the respective spaces. Then using this, we data reduce the sciences and declare the file to output them after plate solving.

Next is to plate-solve the results. I plate-solved it using a local version of Astrometry.net, which is used as a plugin in AIJ. I then adjusted "DP Astrometry settings" for Radius (pixels)", "Filter Radius (pixels)", "Plate Scale (arcsec/pix)", "Tolerance (arcsec/pix)", "Radius (arcmin)", and "SIP Order". At this point, starting the process and leaving it for a few minutes outputted the resulting files into the pipeline file. Plate-solving these images avoids having to align the images.

Next, we generate a Measurement table for the light curve. We import a virtual stack of the plate-solved images, then we use the "Aperture Photometry Tool" to select our target on the first science image. We then are able to see the resulting seeing profile. We then adjust the "Aperture Photometry Settings" based on radii values received from the seeing profile. From here we can perform multi aperture photometry, which should be inputting our radii we took from

seeing profile earlier and using plate-solved images. We selected targets using the process AIJ gives to automatically place apertures.

After this set of analysis procedures, we were left with analyzing and interpreting the light curve.

Conclusion and future work section

There are many pieces of results that we are currently left with, and we have yet to piece them together into a cohesive result. Through this paper, we have discussed our aims to better understand this TOI, and our methods in doing so.

In future work, using the resulting light curves, different charts and tables, the processed data should lead to some conclusion on the TOI as a planetary candidate or not.