

Determining Properties of Variability in AAVSO Reference Star 000-BCF-128

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Abstract

During 2018 ATP summer project *Ensemble Photometry of Exoplanets at the BSU Observatory: Improving Previous Measurements and Streamlining New Ones*, there was an abnormality in the Tres-1b data set on July 18th. Further study revealed that reference star 000-BCF-128 increased in brightness by 0.02 magnitudes. A reference star is a well-studied star with a known constant magnitude that we compare to other targets in the field. An observing campaign request was sent to the AAVSO campaign coordinator to investigate what type of variable star it is or what could have caused short-term variation. Gathered data for star 000-BCF-128 will be used to search for a complete variable cycle in multiple filters so the target's variation period, or lack thereof, can be determined. This information is needed so a report can be created and submitted to the variable star index on the AAVSO website. Star 000-BCF-128 is a trusted and well-studied reference star and if it is variable or its magnitude has changed, it is important for other astronomers to know. The software MaxIm DL's error reporting for ensemble photometry was also investigated, and a software bug discovered.

Introduction

During the 2018 ATP summer research *Ensemble Photometry of Exoplanets at the BSU Observatory: Improving Previous Measurements and Streamlining New Ones*, a method called ensemble photometry was used to improve measurement results while also collecting exoplanet data for the BSU Observatory. Ensemble photometry uses multiple reference stars in the star field to create an artificial reference star to compare the variable star to. This implies that any error or anomaly in a reference star is also added to the artificial reference star when it is created. While analyzing data from July 18th, 2018 one of these anomalies were

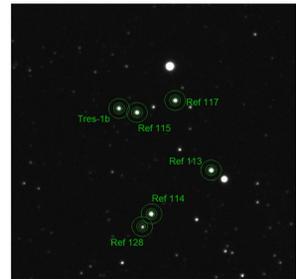


Figure 1: Star field image of ensemble photometry for Tres-1b

Found in the Tres-1b target. It was suspected to be an anomaly because the dip at the end of the curve occurred in the ensemble photometry chart but was not present in the differential photometry chart. A software bug in how Maxim-DL calculates error for ensemble photometry was also found when we noticed reported errors for ensembles matched errors reported for individual stars.

reference star 115 was constant in magnitude, it was used as a comparison star for the others. The first star that was investigated was reference star 114 and the graph came out with the expected increase in brightness (Figure 4). Knowing the magnitude change is at the end of the light curve, only the last 220 images of the data set were used. Then star 115 was used as the object and another star 117 was used as the reference star. The photometry graph came out as a straight line showing them both as constant reference stars (Figure 5). Now knowing that star 117 was constant, it was then used as the reference star for star 114 to confirm its magnitude change and the graph did show an increase in brightness again (figure 6). This information shows that reference star 114, labeled as reference star 000-BCF-128 in the AAVSO database, does have a variation in its magnitude.

Data

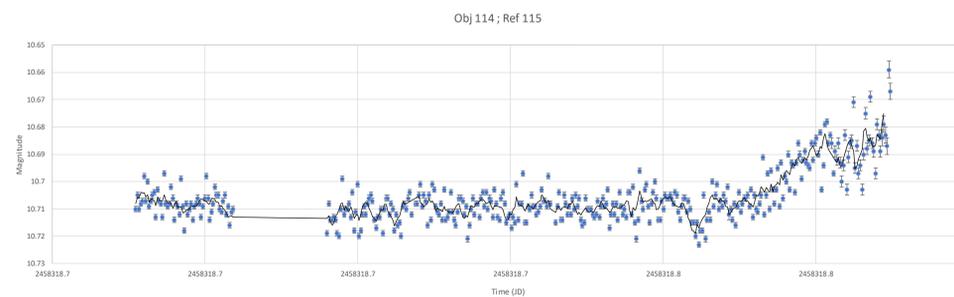


Figure 4: Full light curve of star 114 over a two and a half hour long period and shows an increase in brightness for object 114 of 0.023 (0.002) magnitudes.

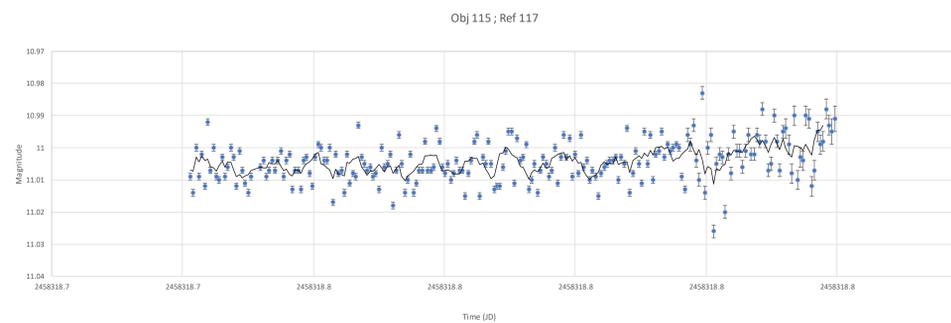


Figure 5: Comparison of reference star 115 to reference star 117 with no significant changes in magnitude show that they are both constant reference stars

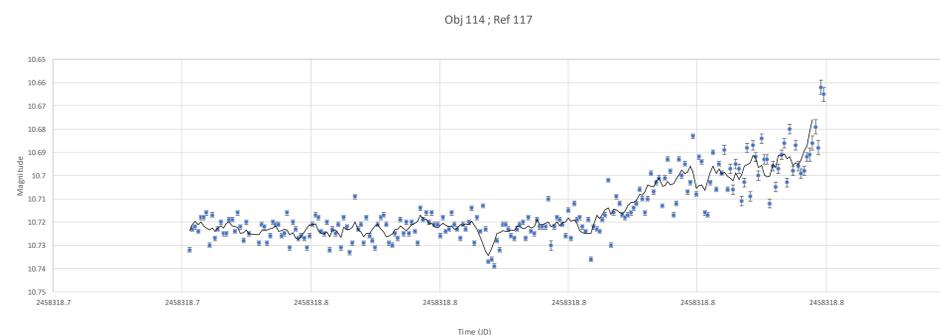


Figure 6: The last hour of data with the points of interest and shows that star 114 increases in brightness of 0.023 (0.002) again with a different reference star. Confirming its variability

Analysis

The next step was to determine the magnitude change of the target of interest and compare its magnitude to the known recorded magnitude of 10.728 found on the AAVSO database. Using the data from figure 4, the magnitudes of the first 300 data points were averaged and got 10.709 (0.001) magnitudes for the lower part of the curve. Taking the average magnitude of the last 50 data points from figure 4 got 10.686 (0.002) magnitudes. This shows an average magnitude difference of 0.023 (0.002). This magnitude difference is much more than what could be blamed on atmospheric changes or increases in ambient brightness since the other investigated stars were not varying in the same way.

Conclusions

The star of interest, 000-BCF-128 can be concluded to be a variable star and not a constant reference star. The AAVSO has this star listed as a reference star with a constant red filter magnitude of 10.728 (0.008)¹⁰. A report of this needs to be created and submitted to the AAVSO database coordinators so they can add this variable star to their system. The software bug that was also found in Maxim DL was reported to their software developers and is being adjusted. The bug was in how Maxim DL calculated error for ensemble photometry. It took error for only one star in an ensemble and used it instead of adding every error in quadrature.

Future Work

More data on reference star 000-BCF-128 needs to be taken and studied so the type of variation can be determined. During this semester research the BSU Observatory's camera had malfunctioned making it unable to collect anymore data. Data can also be requested from the AAVSO through an observer campaign request. With more data we can determine how long the variation is, how frequent it's variation is and what type of variation it is.

Acknowledgments

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References

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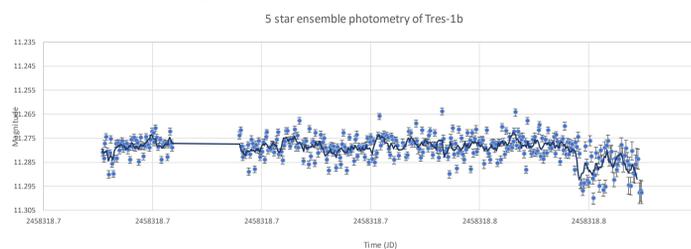


Figure 2: An ensemble photometry graph of Tres-1b with a decrease in brightness of about 0.01 magnitudes at the end of it

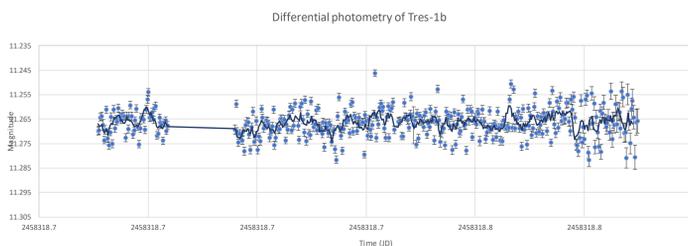


Figure 3: A differential photometry graph of Tres-1b with no decrease in brightness at the end of it

Method

Since the magnitude change was in the ensemble photometry graph and not in the differential photometry graph, then it can be said that neither Tres-1b nor the reference star 115 used for the differential graph are the cause for the change. This left 4 other reference stars to investigate. The change in the light curve also showed Tres-1 decreased in brightness, so the changing reference star would have had to have increased in brightness to give that effect. Knowing that