

University of Puget Sound

## Sound Ideas

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Summer Research

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Summer 2022

### Differential Star Photometry

Austin Glock

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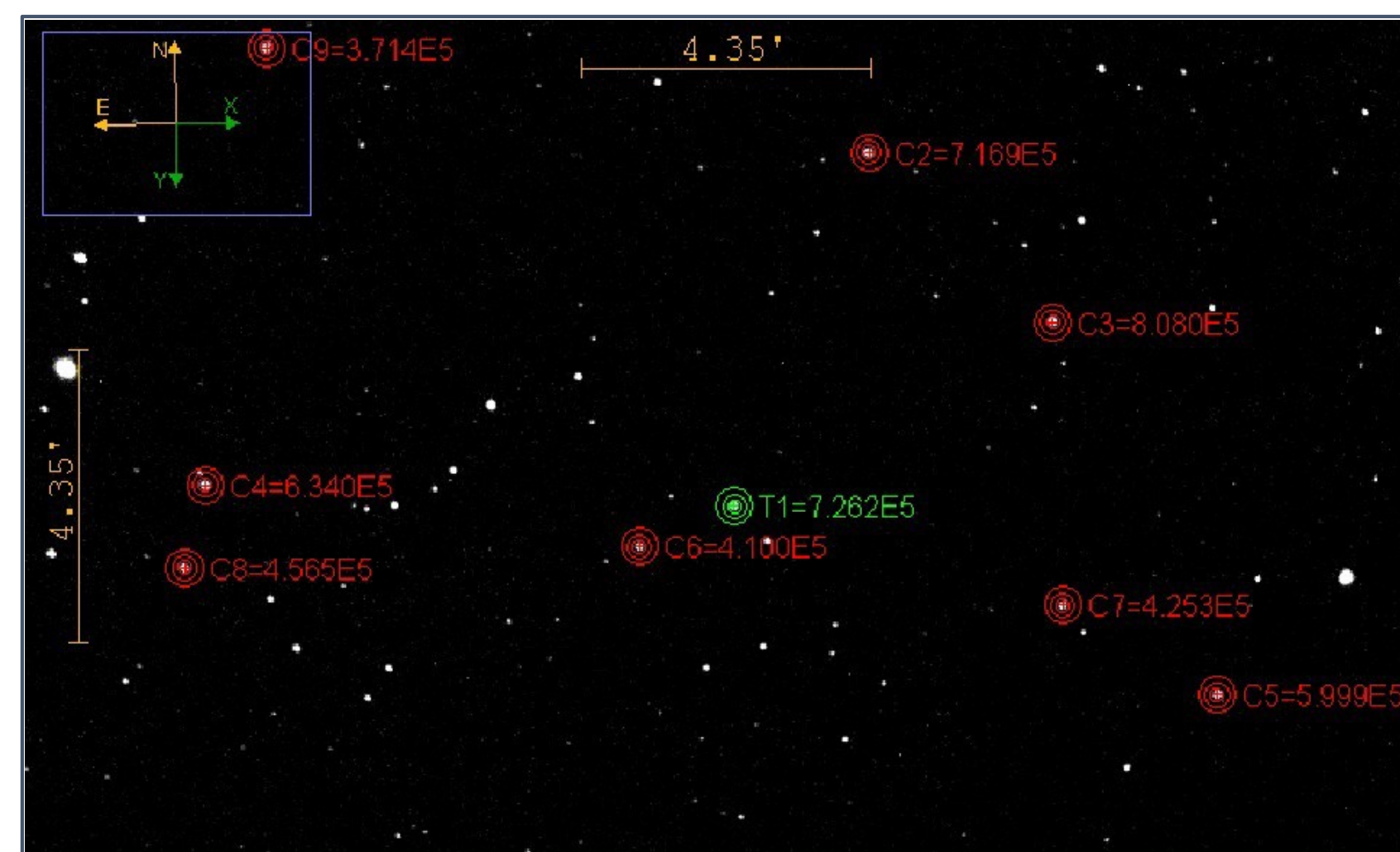
## Introduction

An exoplanet is any planet that orbits a star that is not our own. Currently, there are approximately 5000 confirmed exoplanets, and approximately 8000 suspected exoplanets. [1] Due to the high volume of planets, contributions by amateur astronomers can be the key to more accurate models for exoplanets.

Differential star photometry is the measurement of the difference of two stars' brightness, a variable star and star that does not change in brightness. During an eclipse of a host by an exoplanet, known as a transit, the variable star dims in brightness, allowing for detection.

Through the course of summer research, we observed several exoplanets, three confirmed planets and three host stars with suspected planets.

We found our results for the confirmed planets, those being TrES-3b, CoRoT-2b, and Qatar-1b, were agreeable with the current measurements through NASA's Exoplanet Archive. For our three suspected host stars, known as Tess Objects of Interest (TOI), we found that two of the planets yielded inconclusive measurements. For our third star, the results point at a low likelihood of it hosting an exoplanet.



**Figure 1** – An image taken of TrES-3 and the surrounding comparison stars. TrES-3 is circled in green in the center.

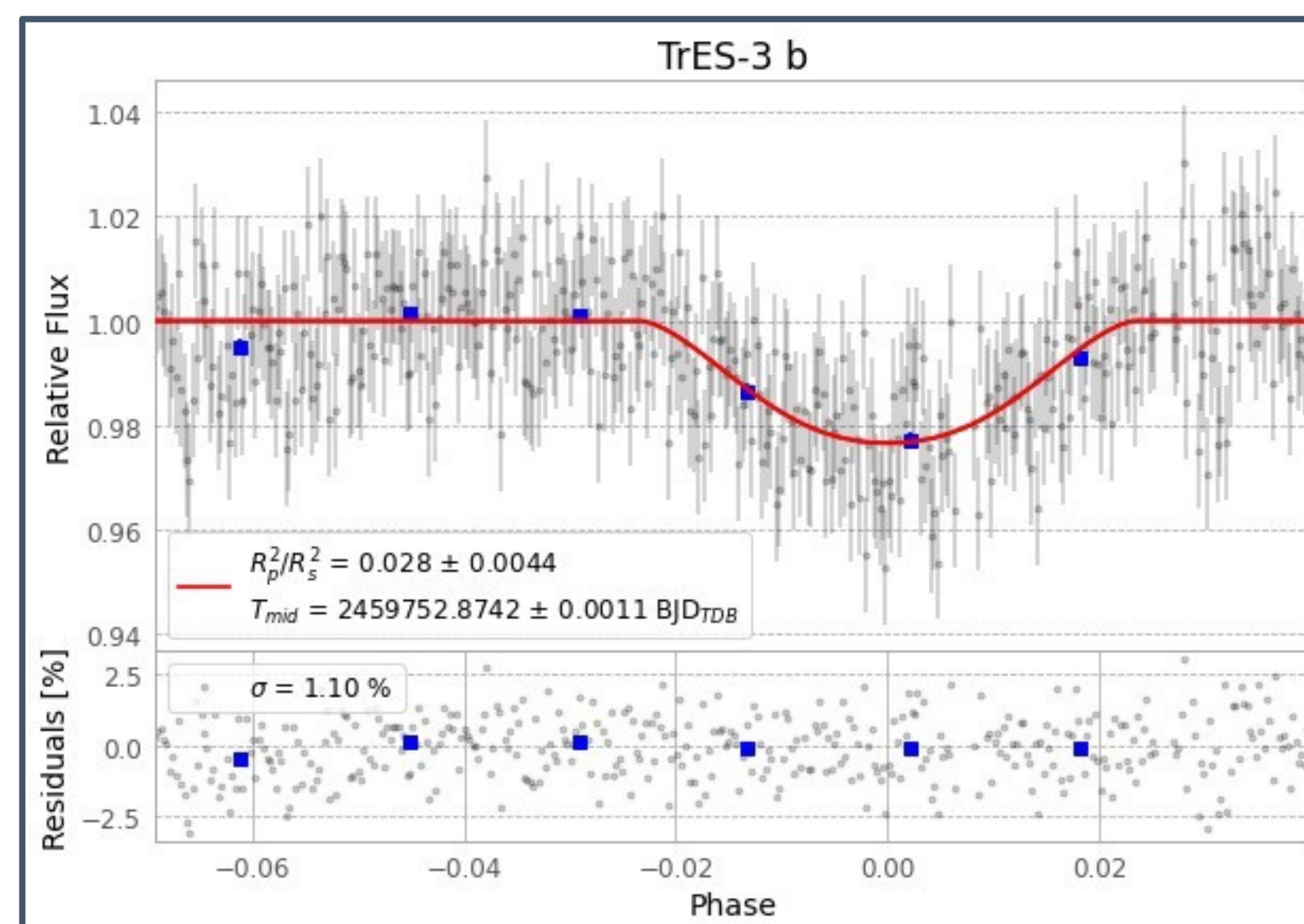
## Objectives

The aim of this summer research project was to observe light curves of variable stars to measure properties of exoplanets around them, but there were many other objectives as well.

### Additional Objectives

- To participate in NASA's Exoplanet Watch Program
- Observe confirmed exoplanets to improve the model
- Observe unconfirmed exoplanet candidates to determine to whether they are exoplanets
- Learn to operate the telescope and perform observations
- Learn image calibration and model fitting

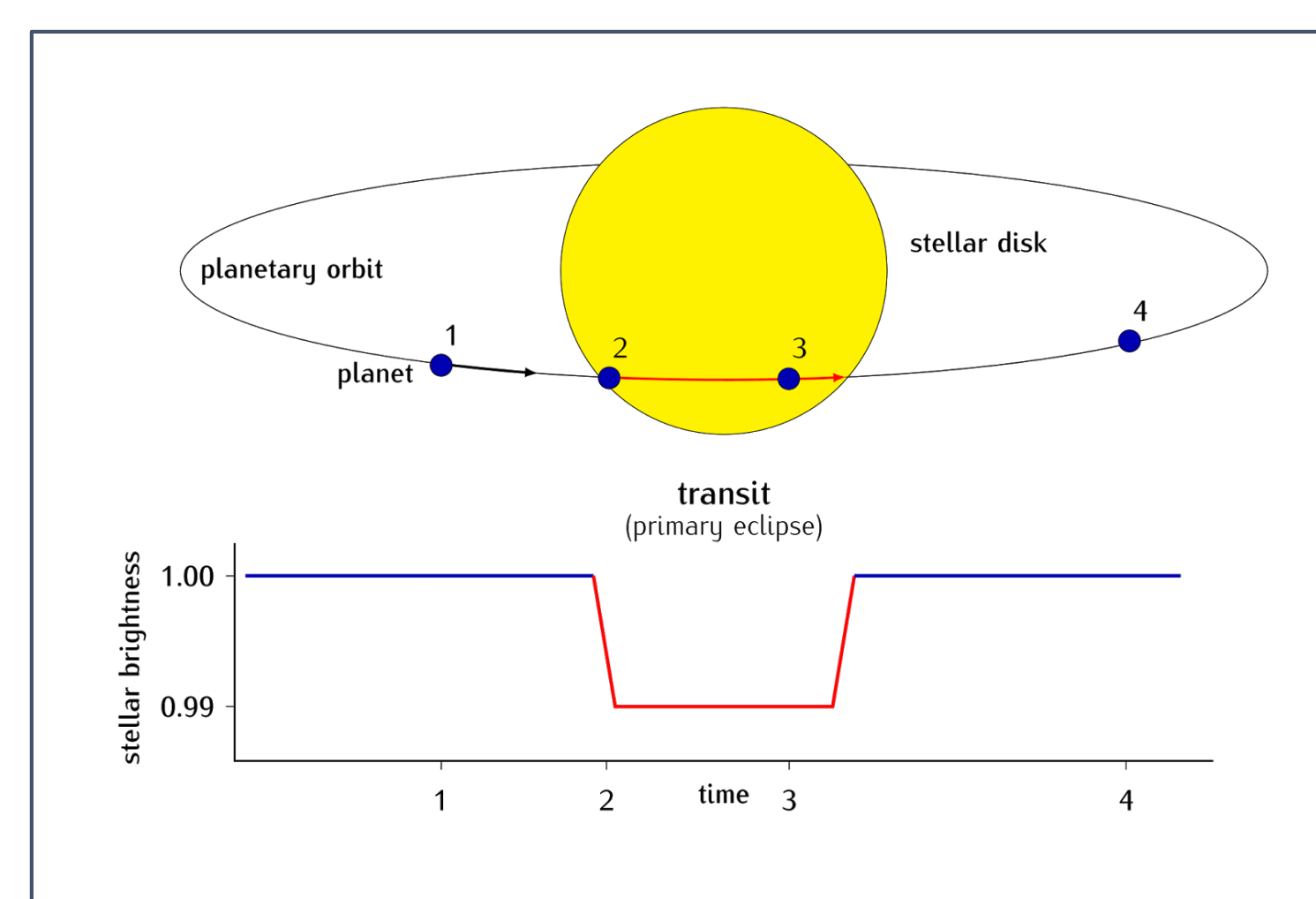
## Results



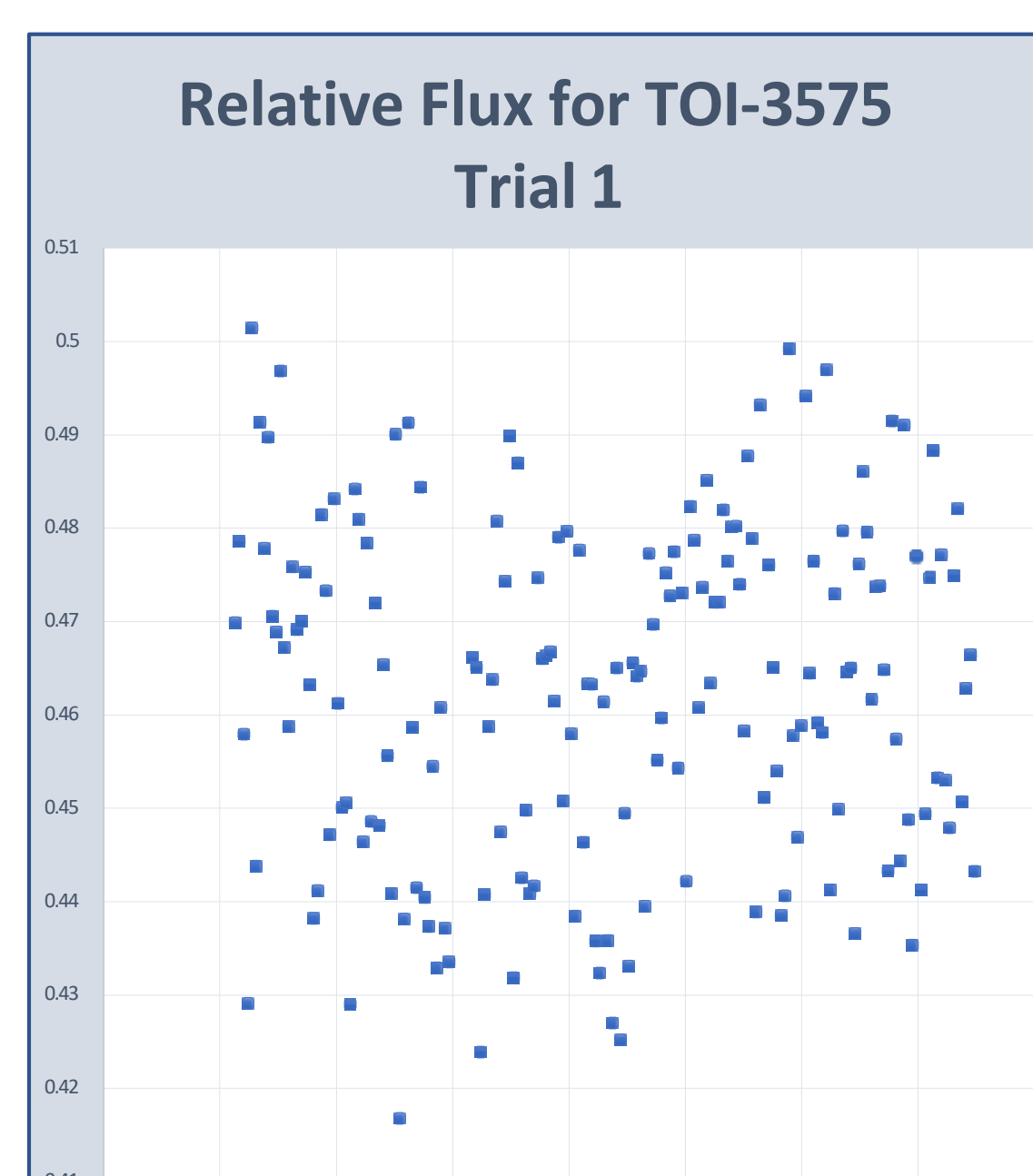
**Figure 2** – The EXOTIC output for the planet TrES-3b

Exoplanet	Measured Value	Known Value
TrES-3b	$0.167 \pm 0.013$	$0.165 \pm 0.002$ [2]
Qatar-1b	$0.174 \pm 0.008$	$0.146 \pm 0.00063$ [3]
CoRoT-2b	$0.164 \pm 0.004$	$0.161 \pm 0.004$ [4]

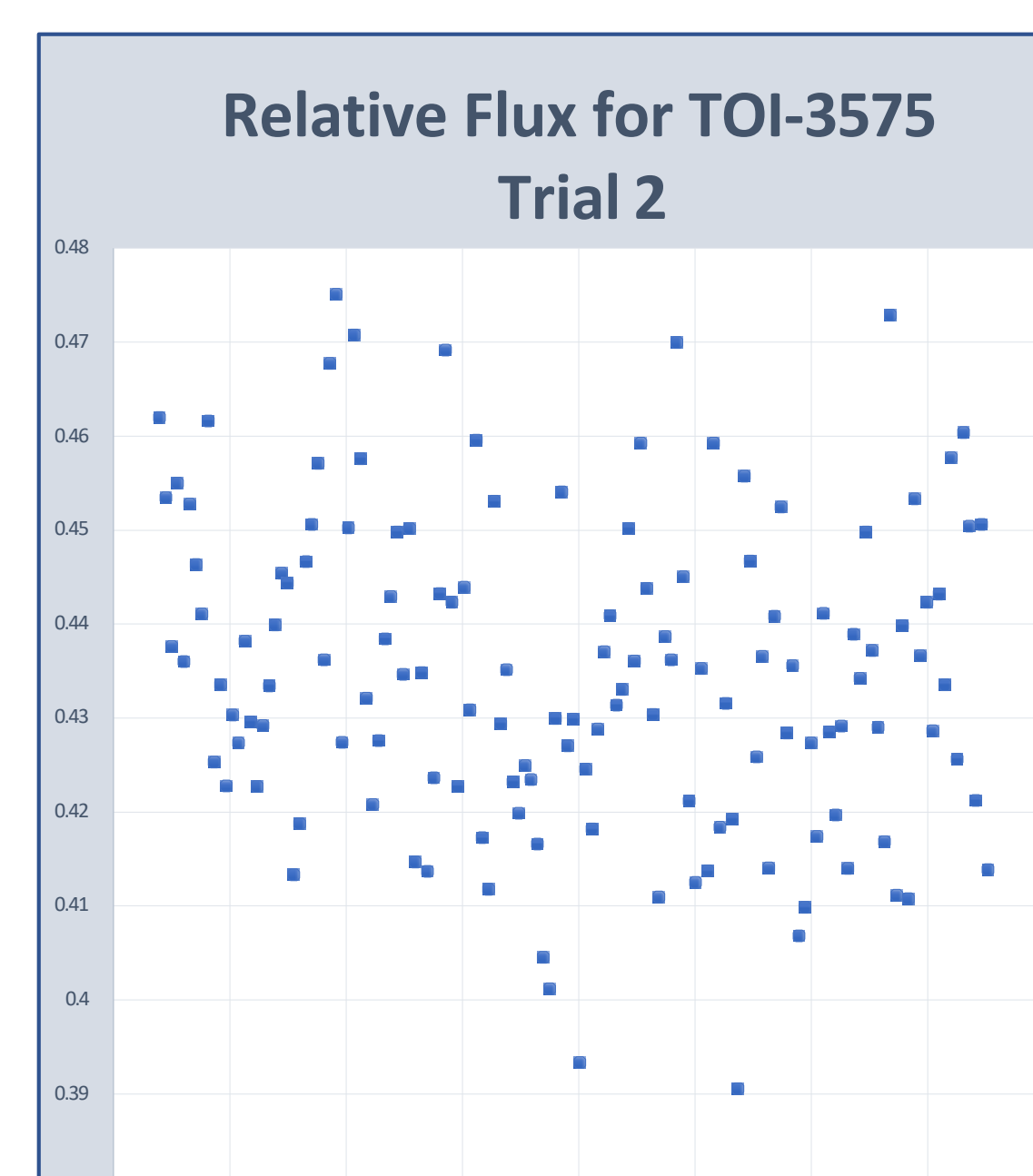
**Table 1** – The ratio of the planet's radius to the star's radius, for our measured value and the recorded value



**Figure 5**– A diagram of the transit method of detection [5]

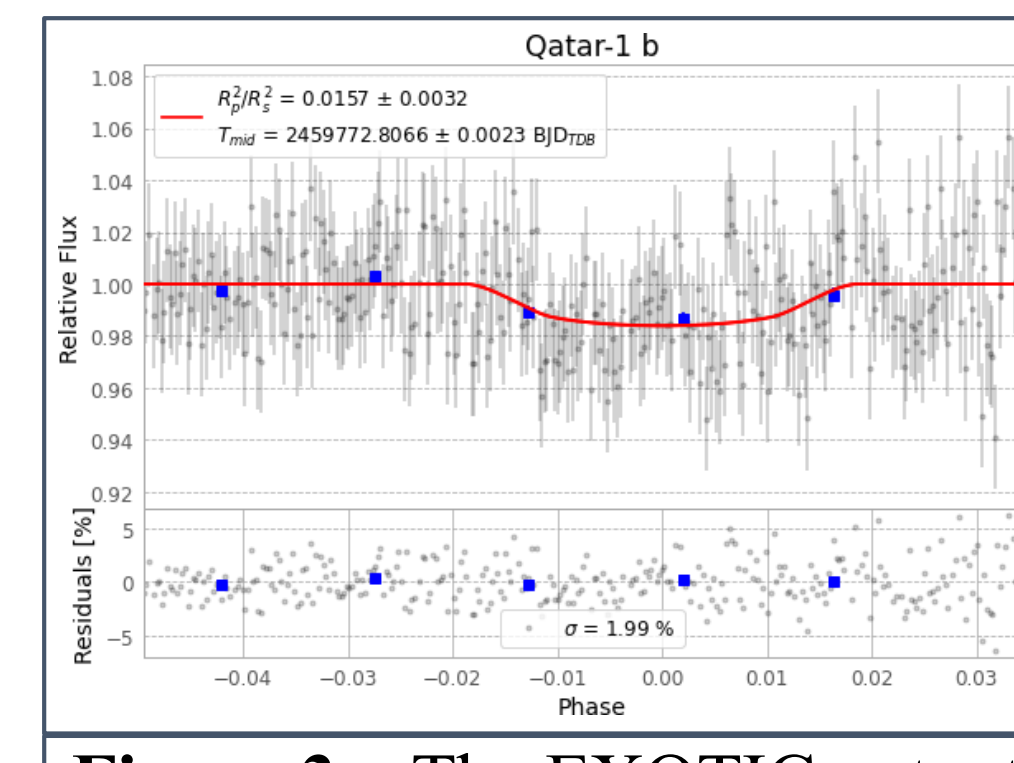


**Figure 6** – The plot of relative flux versus time for TOI-3575 from July 29<sup>th</sup>, 2022

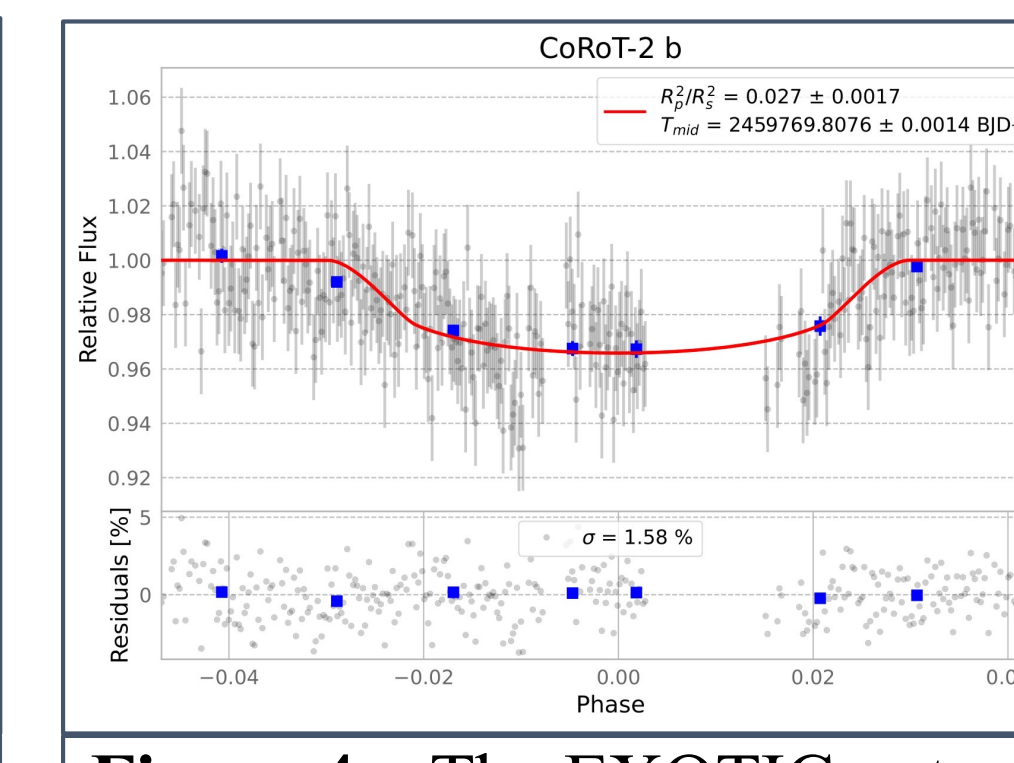


**Figure 7** – The plot of relative flux versus time for TOI-3575 from August 10<sup>th</sup>, 2022

## Confirmed Planets



**Figure 3** – The EXOTIC output for the planet Qatar-1b



**Figure 4** – The EXOTIC output for the planet CoRoT-2b

- By observing confirmed planets, we can refine the data taking process and mitigate error within our observation techniques. Additionally, we can improve the known model for these exoplanets through NASA's Exoplanet Watch program in order to assist professional astronomers in exoplanet research.
- For all three planets, we found the measured data and recorded data to be agreeable with one another. **Table 1** compares measured and known value for the ratio of the exoplanet's radius to the star's radius.
- While TrES-3b produced a relatively clean light curve (**Figure 2**), both Qatar-1b and CoRoT-2b (**Figures 3 & 4**) exhibit some jumpy data, this can be a result of cloudy skies, equipment issues, and many other problems

## Unconfirmed Planets

- In the case of the unconfirmed exoplanets, it turns out to be much more complicated. Due to the high volume of unconfirmed exoplanets, by only observing three suspects a handful of times, the likelihood of detecting an exoplanet is slim.
- Additionally, much of our data yielded inconclusive results due to a lack of comparison stars. Two of the three TOI's that we observed, TOI-1555 and TOI-3514, were deemed inconclusive.
- For our third and final TOI, TOI-5375, several comparison stars were in our field of view. This allowed us to perform the differential photometry on the star, resulting in the two graphs pictured in **figures 6 and 7**.
- Due to both graphs possessing no clear dip in the light curve, we concluded that TOI-5375 does not host an exoplanet based off our observations.

## Conclusion

- While it is unfortunate that we were unable to detect any new exoplanets, a lack of data in this case is good data. In addition to further developing the model for several exoplanets, we were able to conclude that it is likely that TOI-3575 does not host an exoplanet.
- Over the course of the summer, we looked at a fraction of a percent of all suspected exoplanets. In the future, observing more exoplanets, ideally more often, would hopefully yield more conclusive data.
- Beyond observations, I would hope to find a process for fitting a model to an unconfirmed exoplanet. The EXOTIC program that was used is made only for confirmed planets. While we attempted other software, such as AstroimageJ, we were unable to fit a model to any data sets without the EXOTIC program.

## References

- [1] "Exoplanet Exploration: Planets beyond Our Solar System." NASA. NASA, December 17, 2015. <https://exoplanets.nasa.gov/>.
- [2] "TrES-3b." NASA Exoplanet Archive. Cal Tech. Accessed August 15, 2022. <https://exoplanetarchive.ipac.caltech.edu/overview/TrES-3b>.
- [3] "Qatar-1b." NASA Exoplanet Archive. Cal Tech. Accessed August 15, 2022. <https://exoplanetarchive.ipac.caltech.edu/overview/Qatar-1b>.
- [4] "CoRoT-2b." NASA Exoplanet Archive. Cal Tech. Accessed August 15, 2022. <https://exoplanetarchive.ipac.caltech.edu/overview/CoRoT-2b>.
- [5] "The Transit Method." The transit method, January 1, 1970. <http://exoplanet-diagrams.blogspot.com/2015/07/the-transit-method.html>.

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