# Exoplanet Research with NASA's EXOTIC

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## Abstract

The investigation of exoplanets is a relatively recent field with abundant potential. The launch of the Transiting Exoplanet Survey Satellite (TESS) in 2018 marks an exponential increase in the amount of exoplanets we can study. 420 planets have been confirmed as of Feb 21st, 2024, and as of Feb. 16th, 2024, 7,071 exoplanet candidates are actively being researched. While TESS has been pivotal in expanding the field of exoplanet research, it has become equally important for ground-based observations to determine whether the transits detected by TESS are exoplanet systems. The National Aeronautics and Space Administration (NASA) exoplanetary community offers both access to their MicroObservatory telescope and data reduction pipeline, Exoplanet Transit Interpretation Code (EXOTIC), for undergraduate, graduate and civilian scientific researchers to work with. Through the EXOTIC program, we perform multi-aperture photometry with the data given from NASA's MicroObservatory to obtain light curves for target stars with potential exoplanets. These light curves are then analyzed to find incremental and repetitive dips in the flux that represent a system with a transiting exoplanet. As an ongoing project, we are currently working exclusively with the MicroObservatory data. However, this project has the potential of growing to analyze personal data taken by undergraduate students through EXOTIC to detect or confirm exoplanet candidates. As the field of exoplanetary astrophysics grows, this project stands out as a unique student-led, unfunded team with NASA.

## Introduction & Background

- The NASA's EXOTIC allows the public to participate in data reduction, obtaining light curves from known exoplanets.
- Data given from NASA is taken by the MicroObservatory network, which is a worldwide connection of telescopes. For these data sets, the MicroObservatory used is from Whipple Observatory in Arizona, however, future work will include a larger variety of telescopes.
- If a dip in the light curve is discovered to occur at regular intervals and is not otherwise explainable by phenomenon such as transiting dust, a binary pair, or sunspots, an exoplanet is likely to be present.
- We also analyze data that is checking for these phenomenon, such as an orbiting binary companion star, by testing the light curve when the orbiter is behind the main star. If there is a difference in the light curve, we know it is a binary companion instead of an exoplanet.
- The depth of the light curve and the known size of the star are used to measure the radius of the planet.
- The orbital period is determined by the time it takes to transit.
  - Once this is known, Kepler's Third Law is then applied to determine the distance of the planet and its star.

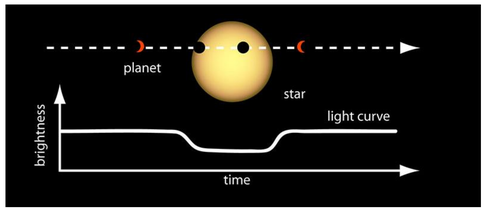


Figure 1: Light Curve Demonstration [1]

## Methods

- Requesting data provides the user with the needed FITS files of target images and dark images for data processing.
- EXOTIC takes an input of data and converts it into light curves.
- Dark frames given in the data are subtracted to take out background noise from the images.
- Calibration stars are selected as a point of reference to find the luminosity of the star of interest.
- EXOTIC has automatic image cleaning, though allows manual removal of poor data.
- With the given star field, EXOTIC performs multi-aperture photometry to obtain the final light curve of the target object.

## Desirable Results [Complete Transit]

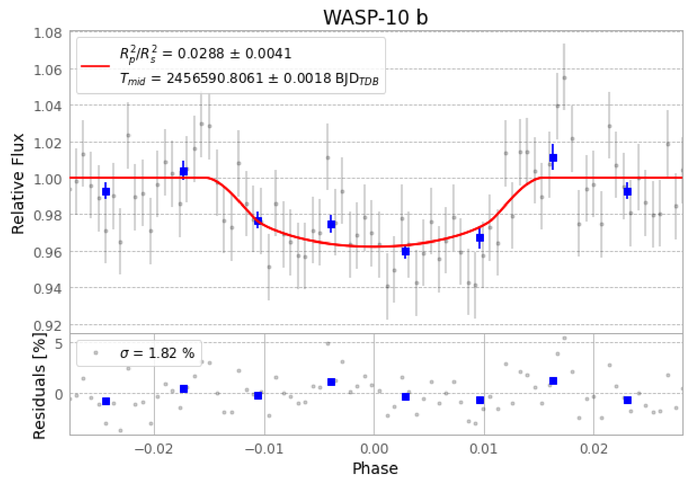


Figure 2: Final light curve and star field of WASP-10 star system.

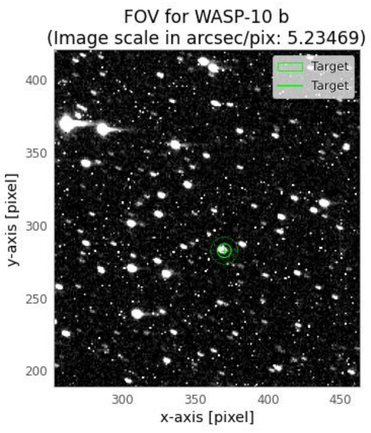


Figure 3: Star field of WASP-10. Target star is indicated by green aperture.

## Undesirable Results [Incomplete Transit]

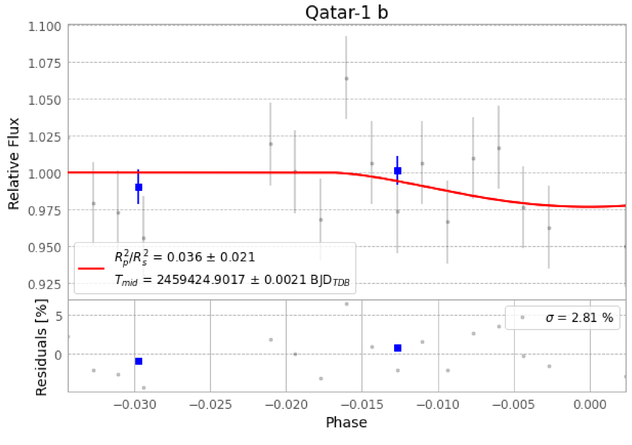


Figure 4: Light curve of Qatar-1 b.

## Discussion

- Although this isn't the best result for determining whether an exoplanet is present, this system is an already confirmed exoplanet.
- This data is instead used for a variety of other sciences, including things like atmospheric spectroscopy.
- Highlighting the start of the transit is still useful and the data is still taken and returned to NASA for further publication.
- Within this data the midpoint is not able to be accurately calculated, so some of the automated data below the dip of the light curve is disregarded.
- The completed transit represents more of what we will eventually be looking for in our own data, as our team plans to work on determining whether or systems have an exoplanet.
- All data is returned to NASA for further analysis.

## Telescope Specifications

- MicroObservatory remote observing network contains:
  - Several 3-foot-tall reflecting telescopes
  - Each telescope equipped with a 6-inch mirror
- Telescopes have CCD detectors instead of eyepieces, which functions as a digital camera chip
  - Records images as picture files with 650 x 500 pixels

## Future Work

- While the data given from NASA is analyzed in the 'standard' version of EXOTIC, there is also an 'advanced' version where personal data can be analyzed.
- In the future, we plan to take our own data of exoplanet candidates at different observatories such as the SARA telescopes or the 1-meter telescope at Embry-Riddle Aeronautical University to possibly confirm the existence of an exoplanet in the given candidate star systems.
- We can also partner with the Astrophotography Committee within the Amateur Astronomy Club to work to photograph potential candidates.

## References

[1] Light Curve of a Planet Transiting Its Star - Exoplanet Exploration: Planets Beyond our Solar System. (n.d.). Exoplanet Exploration: Planets Beyond Our Solar System. https://exoplanets.nasa.gov/resources/280/light-curve-of-a-planet-transiting-its-star/

## Acknowledgements

We would like to thank NASA for providing accessible data and the EXOTIC program to the public so that more individuals can become involved in exoplanet research.