Transit Observation of Extrasolar planet TrES 5b

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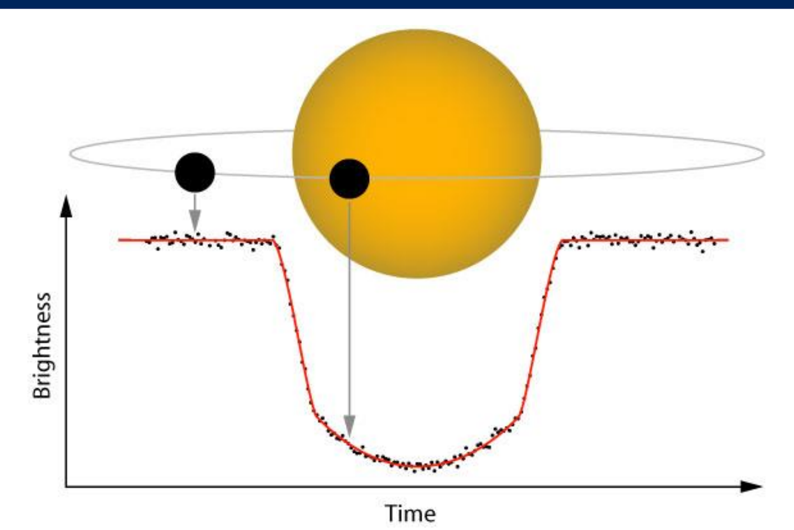
Abstract

TrES 5b is a massive Hot Jupiter that orbits the star GSC 03949-00967 with an orbital period of 1.48 days. Observations of this exoplanet conducted in July 2016 at the Paul and Jane Meyer Observatory, located in Clifton, TX, yielded data that was analyzed using transit photometry in order to calculate the planetary radius. This value was then compared to the current accepted measurements and used in conjunction with other values presented by the original discovery of the extrasolar planet. Furthermore, a background of the importance of extrasolar planets to the understanding of the formation and evolution of planets is discussed. Further work is needed in order to improve parameters and to provide more data for study.

Background

Extra-solar planets are important objects to study because of their role in helping us understand the formation and evolution of planets. Planets observed in evolutionary stages different from those in our Solar System may reveal insights into the formation and evolution of planets in the Solar System. These planets can be observed through varying methods, including radial velocity measurements and photometric transits[1]. These observations are conducted via ground-based surveys or satellite missions.

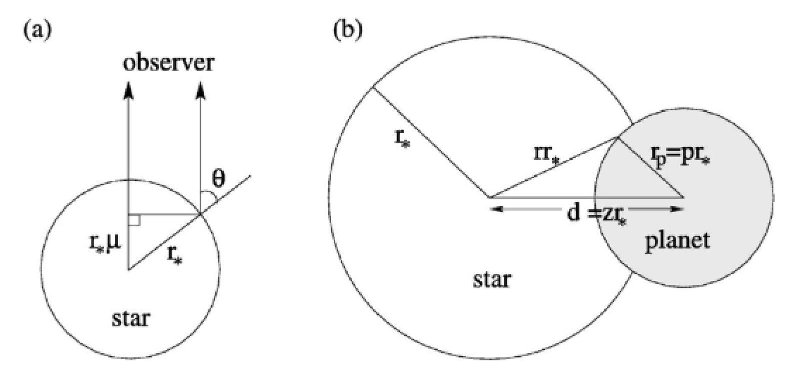
Photometric transits can be detected by observers on Earth when a planet passes between a star and the observer. This causes some of the light emitted from the star to be blocked. This means that the flux received for the duration of transit is reduced as a function of the radius ratio between the star and the exoplanet. This relationship relies on the assumption that the planet does not emit thermal radiation or reflect light from the star[6].



Example of an exoplanet transit light curve[5].

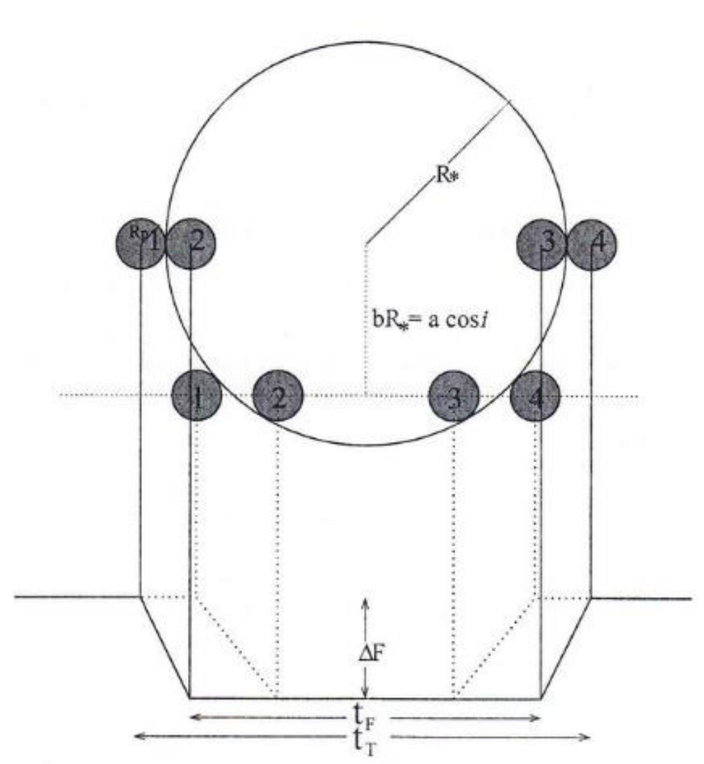
These values provide the information necessary for calculating the radius of the planet.

Known exoplanets are cataloged and of those that have known masses, around 30% have stellar masses greater than or equal to $1.5M_J$[3]. Planets that are more massive are easier to detect, but the drop in the number of massive planets being discovered cannot be explained by the current major selection effects[3].

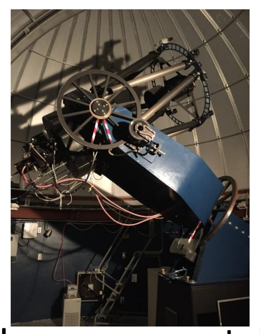


a) Diagram of the transit from above
b) Geometry of the eclipse with respect to the observer[2]

The transit depth ΔF, a transit duration of t_F, total transit duration t_T, Radius of the star R_*, Radius of the planet R_p, impact parameter b, and orbital inclination i[1].



Methods



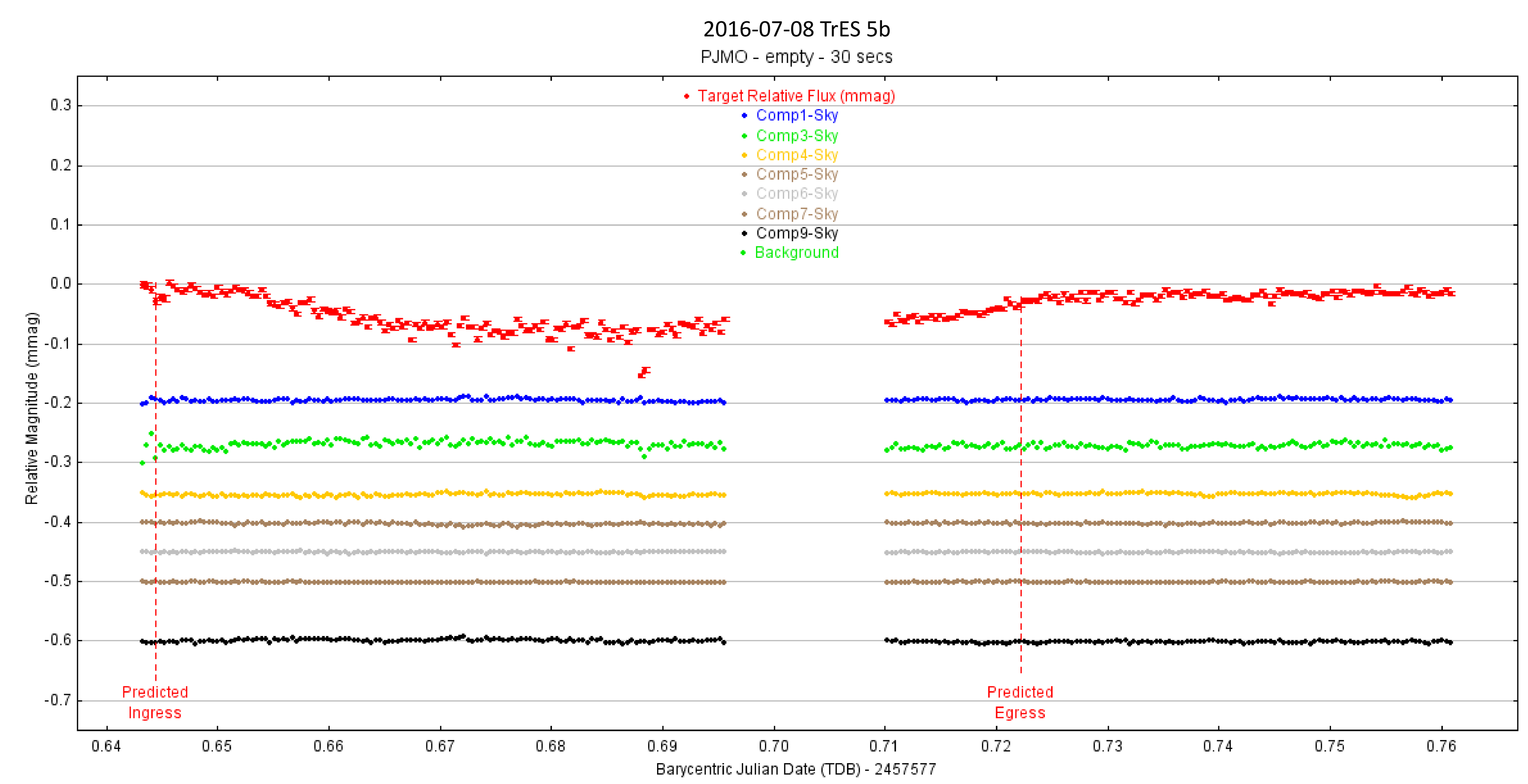
Images were taken at the Central Texas Astronomical Society Paul and Jane Meyer Observatory's 24 inch Telescope[4].

Raw science images were corrected and used in order to produce a light curve through photometry program AstroImageJ. Comparator stars were chosen in order to correct for discrepancies caused by irregularities in the sky.

Images were taken with a 30 second exposure and no filter.

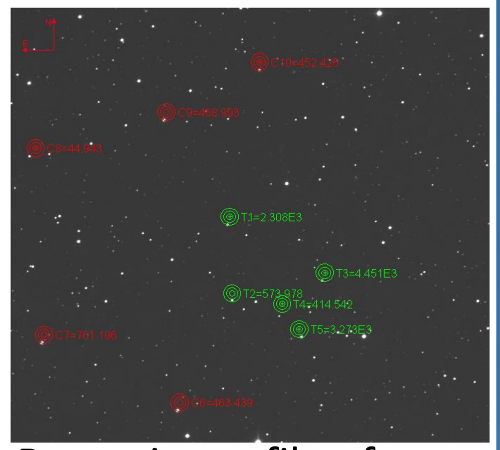
The resulting plot was trimmed to disregard corrupted data caused by the icing over of the telescope.

Results



Light curve of TrES 5b. Red values indicate flux of target star orbited by exoplanet TrES 5b. Other values are the flux measurements of comparator stars. The gap in the data was due to a mechanical malfunction of the telescope's nitrogen cooling system.

Finder chart indicating target star GSC 03949-00967. Apparent magnitude of 13.72.



Raw science file of target star T1. All red values and green values besides T1 are comparator stars. Over the course of the observation over 430 images were taken.

Change in total observed flux:

$$\Delta F = \frac{F_{no\ transit} - F_{transit}}{F_{no\ transit}}$$

$$\Delta F = 0.02036$$

Radius Ratio:

$$\frac{R_p}{R_{sun}} = \frac{R_*}{R_{sun}}\sqrt{\Delta F}$$

Planetary Radius:

$$R_p = R_*\sqrt{\Delta F}$$

The original discovery of TrES 5b resulted in a planetary radius of $R_p = 8.355 \times 10^7 \mathrm{m}$ and through radial velocity measurements a mass of $M_p = 3.375 \times 10^{27} \mathrm{kg}$ or $M_p = 1.778 M_J$[3].

Precise photometry resulted in a planetary radius of:

$$R_p = 8.599 \times 10^7 \mathrm{m}$$

Percent Error: 2%

Conclusion

- Exoplanet TrES 5b can be considered a Hot Jupiter.
- Precise photometry is capable of detecting exoplanets even with faint stars.
- Radial velocity observations of the planet are necessary in order to obtain the mass of the planet as well as spectroscopy of the host star.

Future Work

- Due to technical malfunctions the observation was interrupted.
- More images could be collected, over a number of days in order to provide more data.
- The project could benefit from introducing the radial velocity method in order to calculate the mass of the planet. It would also benefit from spectroscopy of the host star.

Support

Dr. Dwight Russell (Baylor University Physics and Astronomy Department)
Richard Campbell (Baylor University Engineering Department)
Willie Strickland and the Central Texas Astronomical Society
Dr. Truell Hyde (Center for Astrophysics, Space Physics, and Engineering Research)
Dr. Lorin Matthews (Center for Astrophysics, Space Physics, and Engineering Research)
Sherri Honza
This research was supported by the National Science Foundation

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