# Observing the Transit of Nearby Exoplanet Qatar-2b Using CCD Photometry via Robotic Telescopes

By: Aaron Speyer
Faculty Sponsor: Dr. Enrique Gomez, Department of Chemistry and Physics

**Background**

The first discovery of exoplanets orbiting pulsar PSR B1257+12 occurred in 1992. Since then, there has been an increased effort to identify the transits of exoplanets around distant stars. Astronomers at the University of Arizona in 2014 were the first to make images of an exoplanet using Charge Coupled Device (CCD) photon detectors, which are "sensitive enough to detect a 2-3% drop in the amount of light" (Dussault, M. et al.), rather than traditional eyepieces. Robotic telescopes from the Harvard MicroObservatory Telescope Network focus collected light onto CCD detectors to image "planets in visible light, which has not been possible previously with Earth based telescopes" (NASA Exoplanet Exploration). Astronomers' ability to use CCD photometry to view exoplanets in visible light rather than infrared light brings us one step closer to one day discovering what scientists refer to as a "pale blue dot," or a distant Earth like exoplanet that reflects blue light, indicating an atmosphere that may indicate a habitable planet.

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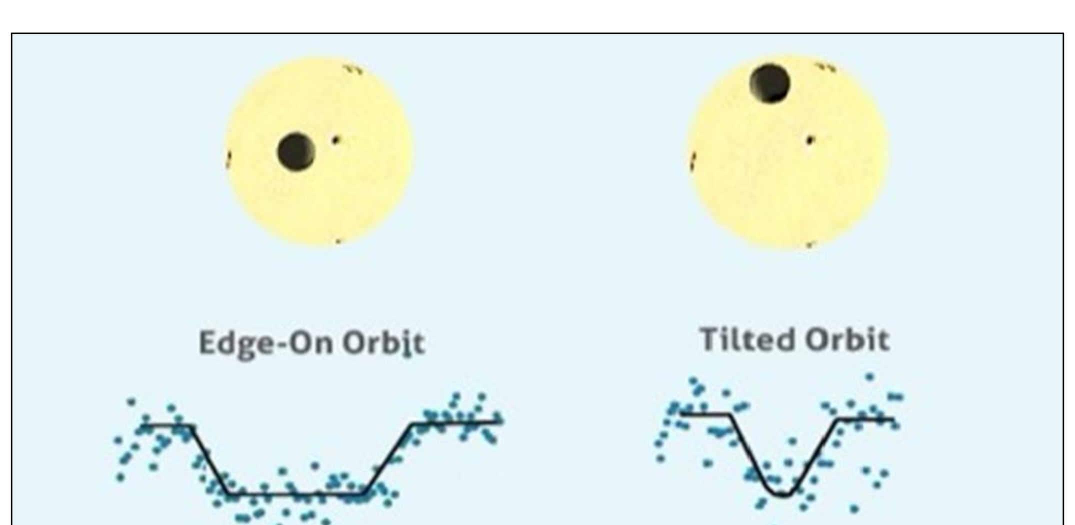
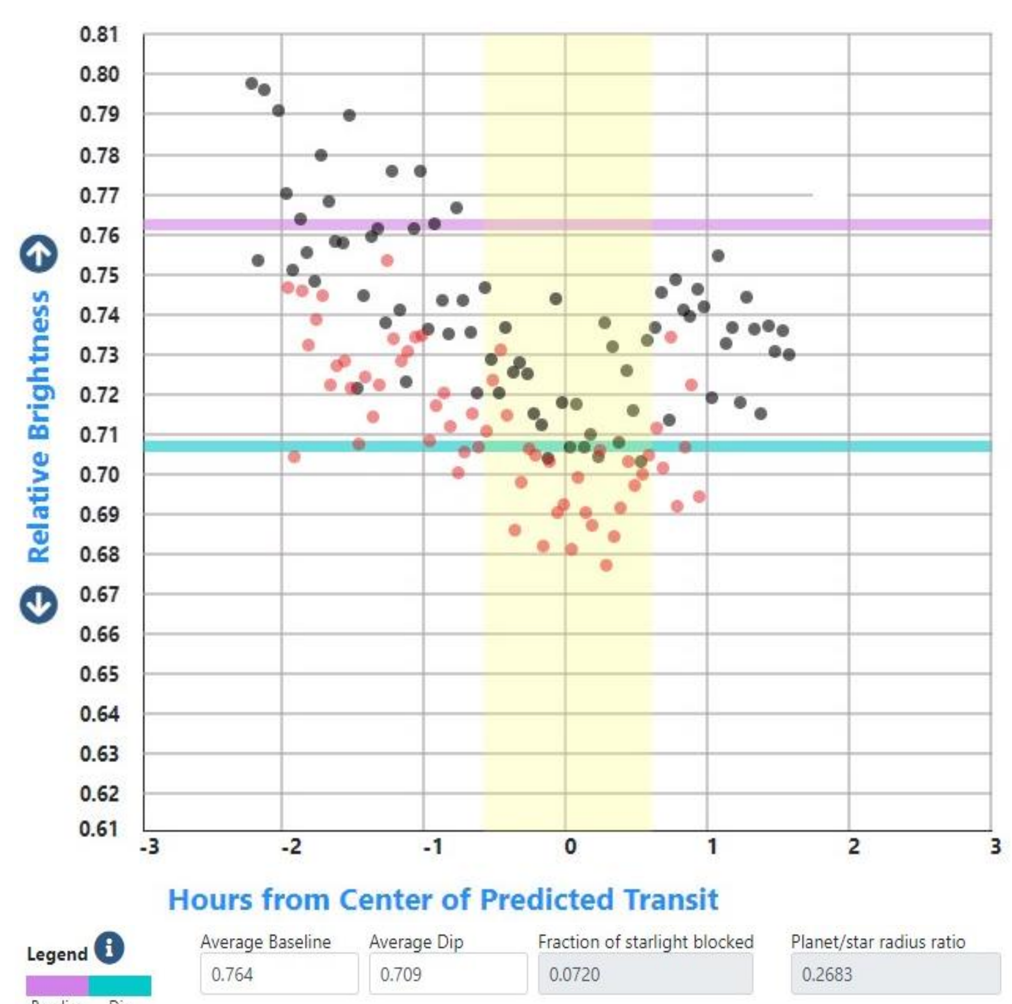
## Procedure

We used the DIY Planet Search program to schedule a date and a transit around a target star that was visible enough to observe. Qatar-2b orbits a high proper-motion star. We controlled a robotic telescope named Cecilia in Amado, AZ to take a series of images recording Qatar-2b's transit. Each image and calculation of the relative transit was then recorded and compiled into a plot graph to demonstrate the transit of Qatar-2b. We determined the average baseline and dip of the transit and used these values to calculate Qatar-2b's size by defining the fraction of the star's light blocked by Qatar-2b and taking the square root of this number. Qatar-2b's orbit is tilted as the shape of the plot graph is U-shaped, but narrow. We used Newton's Law of Gravitation to derive a formula $r = \frac{GM}{v^2}$ that allowed us to find the radius of Qatar-2's orbit.

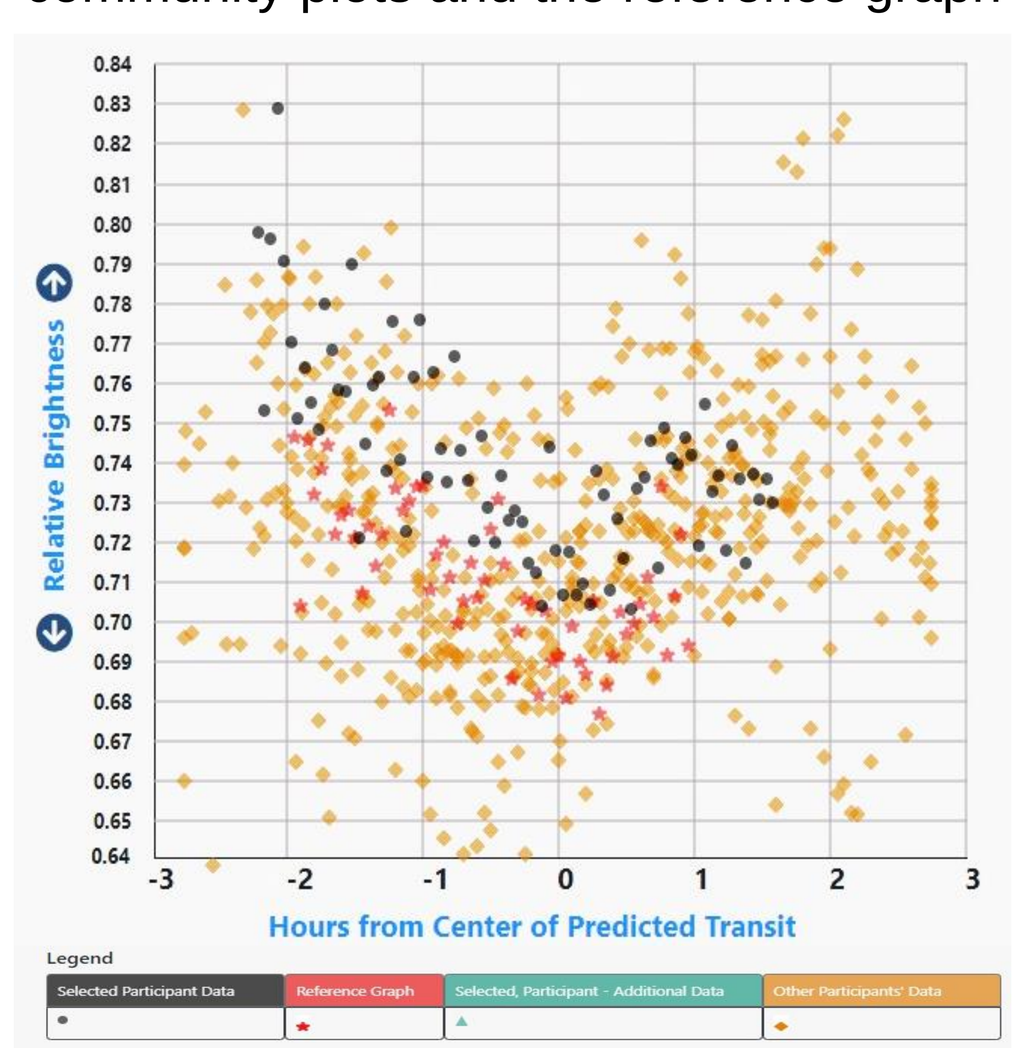
Demonstration of planet's transit and plot graph output and trendline




Our plot of star's brightness as Qatar-2 orbits in front




Our plot of Qatar-2's transit compared to community plots and the reference graph




Map of the target star, two comparison stars, and two dark areas of the night sky

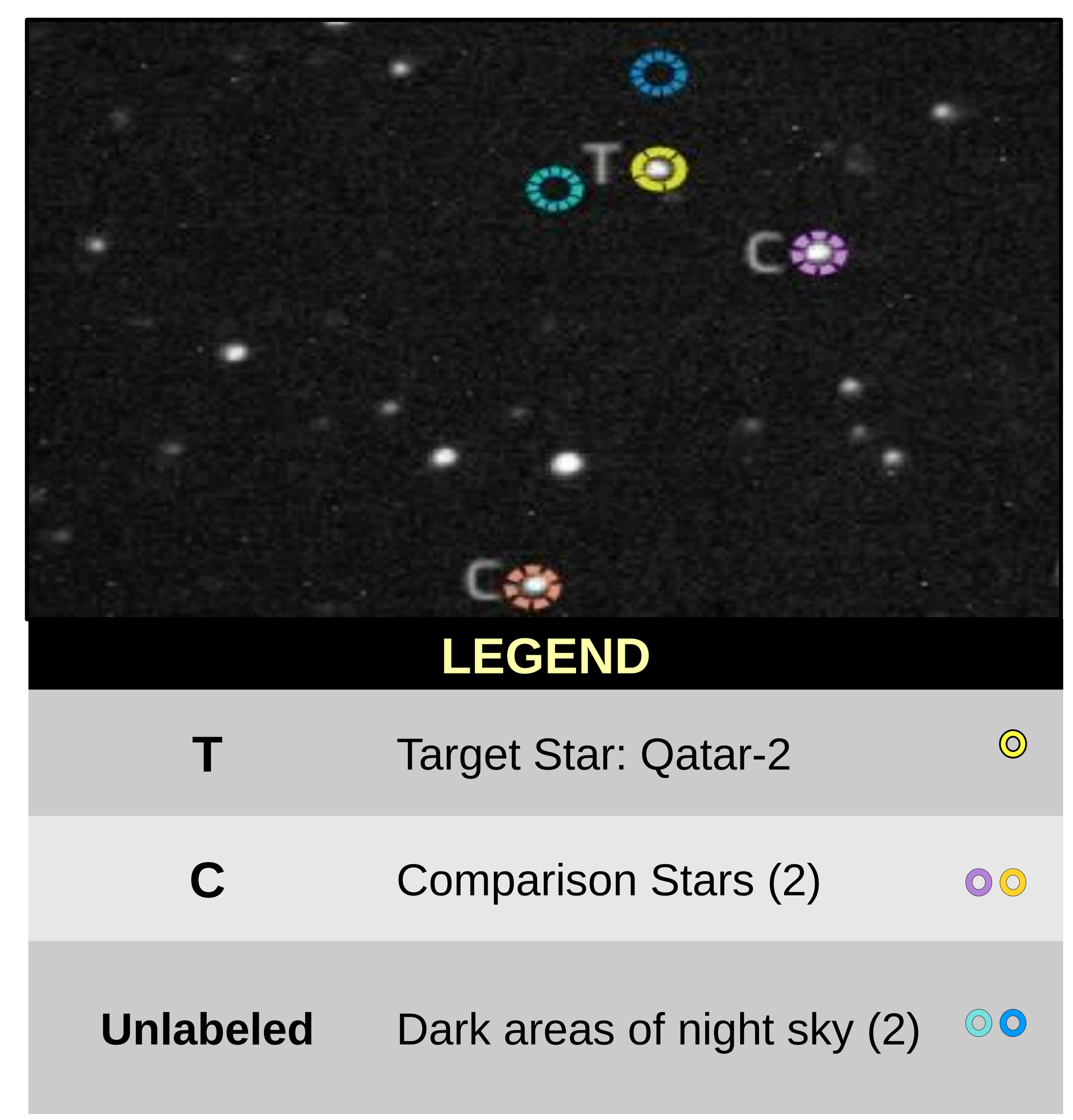
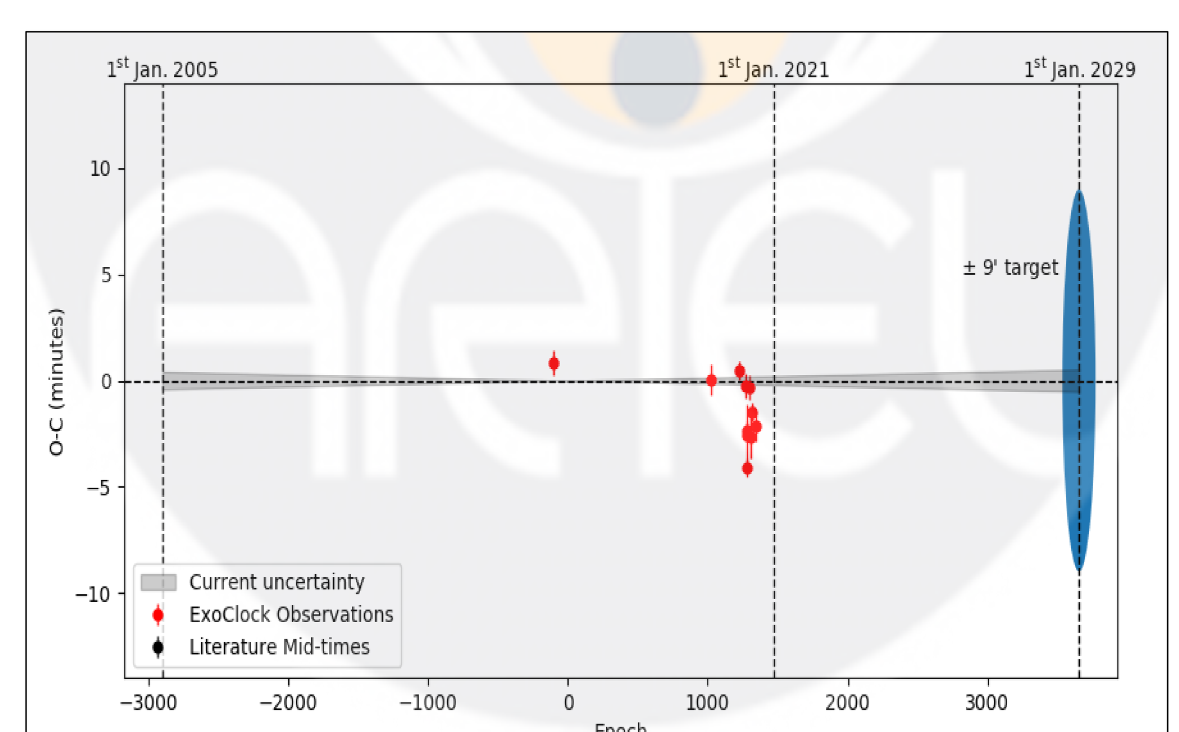



Chart showing observations and a possible drift of Qatar-2's transit in front of its star




## Discussion

Our observations of exoplanet Qatar-2's transit confirm its transit in front of a distant star, and it allowed us to notice a slight drift in its transit. As Qatar-2's transit crosses in front of the star, the relative brightness of each data point becomes lower, creating the U-shaped graph that matches the predicted transit. We noticed that our graph seemed to indicate that the eclipse was beginning earlier than anticipated – something that may be consistent with a drift. This could be due to several factors, such as the planet being too close to its star or solar winds causing mass loss for the planet. By combining our plot graph with those published by others in the scientific community, we are able to create a collective graph that shows the relative brightness of the distant star before and after Qatar-2's transit. The deeper the dip of the graph, the larger Qatar-2 is. If the dip is wide, we know the orbit is "edge-on", and if the dip is short, the orbit is tilted. We found that Qatar-2's orbit is tilted and that its eclipse occurred earlier than expected.

## References

Astronomers make the first Earth-based CCD images of an exoplanet. (2014, March 05). NASA Exoplanet Exploration Retrieved from https://exoplanets.nasa.gov/news/151/astronomers-make-the-first-earth-based-ccd-images-of-an-exoplanet/

Data from the Harvard MicroObservatory Telescope Network, Dussault, M. et al. 2020 NASA's Universe of Learning, Caltech/IPAC, Jet Propulsion Laboratory, Smithsonian Astrophysical Observatory, and Sonoma State University. Available at https://www.cfa.harvard.edu/MicroObservatory/