Transit Photometry: Bringing James Webb Space Telescope Science to NextGen

Arushi Nath. 2023 and 2022 Canada-Wide Science Fair Top Award Winner. Grade 9. arushi@monitormyplanet.com Twitter @wonrobot



Open science and robotic telescopes bring new opportunities for youth and citizen scientists to monitor and improve the ephemerides of transiting exoplanets. Analysis of transit depth and duration would improve our information on their size and orbital characteristics. It will also benefit ongoing and future space missions like JWST, Ariel and Twinkle, as improved ephemerides mean better allocation of their time to observe the transits.

Background: From Asteroids to Transit Photometry

I developed photometry algorithms to determine the physical properties of asteroids by combining data from robotic telescopes, school math and open science. I successfully applied them to determine the physical properties of the Didymos binary asteroid and measure the success of the NASA Double Asteroid Redirection Test (DART) Mission.

The steady rise in the number and type of exoplanets is outpacing our abilities to characterize them, opening new citizen science opportunities. I am expanding my photometry algorithms to transit photometry using open science. It will allow citizen scientists to accelerate the pace of analysis of exoplanets by improving ephemerides and flagging exoplanets of interest to ongoing and upcoming space missions.

Project Goals

- Develop algorithms to improve the ephemerides of transiting exoplanets by combining data from robotic telescopes and using school math, and open science
- Determine the adequacy of smaller aperture telescopes in finding differences in relative radius of transiting exoplanets when observed with multiple filters

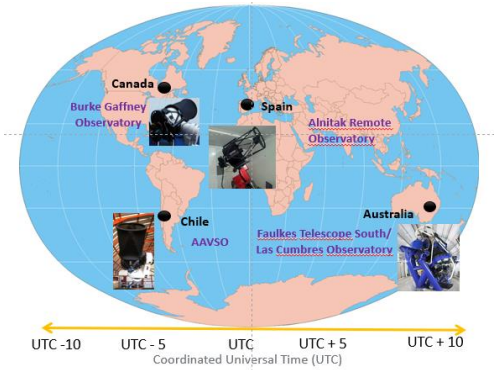
Observing Transits Using Robotic Telescopes

Telescopes at different latitudes and longitudes (Australia, Canada, Chile and Spain) operated by Faulkes Telescope Project (UK), Burke Gaffney Observatory (Canada), American Association of Variable Star Observers (AAVSO) and Alnitak Remote Observatories (Spain) are being used to observes the exoplanetary transits and gather data.

Querying Open Datasets for Transit Photometry

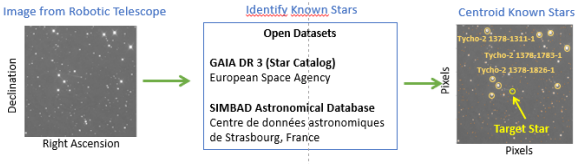
To find transits of exoplanets that are observable from a given location at a given time, I am using several databases including the Transit Finder of the Swarthmore College and ExoClock database maintained by ARIEL Space Telescope Ephemerides Working Group. In addition, I use the GAIA and Simbad dataset for identifying the target star and comparison stars for my observations.

Network of Robotic Telescopes Used for the Project

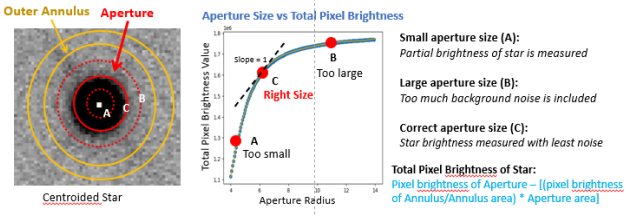


Methodology: Transit Photometry

Identify and Centroid Target Star in Images from Robotic Telescopes

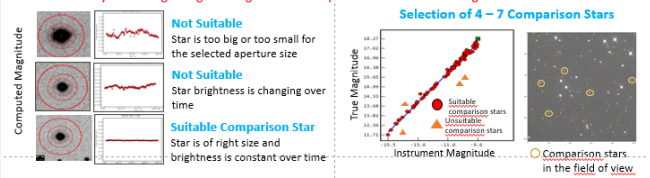


Find Aperture Size to Measure Total Pixel Brightness of the Target Star (Differential Photometry)



Using Comparison Stars to Determine Computed Magnitude of Parent Star

Observed brightness of the star will change during transit but would be affected by seeing conditions. The variations can be reduced by measuring changes in brightness of comparison stars of known magnitudes in the field of view



Math, Open Data, Open Communities, and Programming Tools Being Used

Math

Area of Circle

Median, Weighted Mean, Standard Deviation

Slope, Logarithm, Modulo

Open Data

Transit Finder: https://astro.swarthmore.edu/transits/

ExoClock https://www.exoclock.space/

EUREKA JWST Data Pipeline https://eurekadocs.readthedocs.io/en/latest/

Open Communities

Exoplanet Watch/ EXOTIC

American Association of Variable Star Observers (AAVSO)

British Astronomical Association and Royal Astronomical Society of Canada

Programming

python, NumPy, matplotlib, astropy

DATA: Primary Observations Obtained (15+ hours)

Date	Telescope	Transiting Exoplanet	Observation (hours)	Filter
2023-07-07	Burke Gaffney Observatory	KPS-1b	3	R
2023-08-14	Burke Gaffney Observatory	Kelt-16b	3.2	B
2023-08-26	Anitak Telescope	XO-6b	1	R
2023-08-28	Anitak Telescope	Wasp-48b	1	R
2023-08-29	Anitak Telescope	Wasp-48b	1	B
2023-08-31	Anitak Telescope	Wasp-10b	2	R
2023-09-01	Anitak Telescope	TrES-2b	2	B
2023-09-03	Anitak Telescope	Wasp-33b	2	R
2023-09-05	Anitak Telescope	TOI-1333b	1.5	B

Preliminary Results

Applying my algorithm and that of Exoplanet Watch (EXOTIC) and ExoWorlds Spies (HOPS), I obtained transit curves for many exoplanets. The analysis is ongoing, and I plan to take observations using different filters and compare them.

