Project Proposal: Confirming Exoplanet Transit Signals Through Ground-based Observational Image Analysis

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Search for periodic exoplanet transits through ground based observational image analysis and search for time varying transit signals in select star systems.

I. INTRODUCTION

We propose to confirm the existence of a known exoplanet and measure some of its properties. There are several methods for determining the existice of an exoplanet; these include direct imaging, the doppler method, gravitational microlensing, and the transit method. We will use the transit method for our observations. The transit method of exoplanet detection takes advantage of the exoplanet's orbital geometry relative to an Earth observer's line of sight. This method requires the exoplanet to pass directly between the Earth and the host star. As the exoplanet intersects the line of sight to the star, there is a decrease in the observed flux from the star.

The decrease in brightness is directly proportional to the cross-sectional area of the planet compared to the star - assuming a uniformly illuminated disk of the star with no limb darkening and that the $\Delta Flux$ is taken at the centroid, c of the transit signal.

$$\Delta Flux_{t=c} = \frac{A_p}{A_s} = \frac{\pi R_p^2}{\pi R_s^2} = \left(\frac{R_p}{R_s}\right)^2 \tag{1}$$

If the size of the star is known then the radius of the candidate exoplanet can be determined.

Since the first exoplanet discoveries in 1992, scientists and observers have quickly complied a vast expanse of knowledge in exoplanetology including invaluable catalogs of exoplanet candidates. Such examples include professional endeavors such as the Kepler Space Telescope and the James Webb Telescope, and amateur efforts such as the Exoplanet Transit Database from the Czech Astronomical Society. Using these resources, it is possible to begin making observations of stars that host exoplanet candidates in order to confirm past observations of their existence. It may even be possible to determine if a time varying transit signal is observable for the chosen systems. This time varying signal would likely be indicative of another exoplanet candidate in the observed star systems. It is similar to the precession of Mercury's orbit due to the gravitational influence of Jupiter.

II. SETUP

The data obtained from the images will allow for several of the candidate exoplanet properties to be estimated including: period of oribt, semi-major axis, effective planetary surface temperature, spatial relation to the habitable zone, the planetary radius, the exoplanet's density, and the potentially the exoplanet's mass.

If the radius of the star is known then it is possible to determine the radius of the observed planet using Equation(1). Am important parameter to consider is the period of the planet. There are two possible outcomes from our determination of the period. First, if the period is constant then we may determine the semi-major axis of its orbit and a few other parameters. Second, if the periods varies from orbit to orbit then there is most likely other planets in the system whose gravitational influence is affecting the observed exoplanet's orbit.

Criteria for candidate host stars
For candidate host stars around $40^\circ N$ we need an HA that doesnt go past 3 hrs at end of transit duration.
we want to look at a declination that is within 30degrees of zenith $\rightarrow$ 40 $\pm$30 = Dec:[10,70]
we know that RA = LST = UT - 7hrs. On March 21st, RA in england at midnight is 0hr. seven months later on Oct 21st with the sky moving 2 deg/mo, midnight in england has an RA of 14hr. In boulder that is (-7) = RA 7hr at midnight. Observing sessions that start at Dusk $\approx$8pm will be at LST(local) = 3hr, and lasting until twilight $\approx$5am will be at LST = 13hr. If, at the beginning of the observing session, we observe a transit at an HA of -3, we will be able to observe the entire transit if it is less than 6 hours long. For a transit with a duration of three hours, an HA of less than 0hr will allow us to observe the entire transit.
we will also require three comparison stars for photometric comparison of magnitudes. The difference between the known magnitudes of the host stars and their instrumental magnitudes (acquired during data analysis) will allow us to calculate the magnitude offset between instrumental and true magnitudes for our candidate star hosting an exoplanet. From these magnitudes, the flux will be determined using IRAF analysis software for each frame of the observation.

III. DESCRIPTION OF OBSERVATIONS

Once a candidate star is chosen for observation, the specific conditions of our observing will slightly change. The nights needed for observation will be throughout November 2015; with this in mind, a potential exoplanet candidate must be chosen within a range of RA and Dec that will be observable from the Sommers-Bauch Observatory at the University of Colorado at Boulder. The RA coordinates are determined by the local sidereal time at local midnight. should be between 0h and 15h for optimal observations. Likewise, the declination of candidate stars is $40^\circ N \pm 30^\circ = [10^\circ N, 70^\circ N]$. The field of view of the SBO 24" telescope is approximately 26 square arcminutes, which will need to include the host star of the exoplanet candidate and a good comparison star. An online exoplanet database, *Exoplanets Data Explorer* (http://exoplanets.org/table)will be used to determine a list of exoplanet candidates. The criteria for these candidates is (1) that the host star be between magnitude 8 and 12 and (2) that the exoplanet candidate have a transit depth of at least 1% decrease in flux. The right ascension of the candidate stars should lie between 0hr and 12hr, and the declination should lie between +10 and +70 degrees. With these criteria, a well defined light curve for the entire transit duration and high SNR can be established for the transit profile.

IV. RESULTS

The image analysis shows that the period of the observed exoplanets is [**SOMETHING**].

The signal to noise ratio is [**SOMETHING**].

The measured properties are [**SOMETHING**].

The calculated properties in There [**WAS / WAS NOT**] transit time variation signals observed.

V. CONCLUSION ("KNOCK-DOWN")

Our measurements allow us to constrain the following important properties to [**THIS / THESE**] systems [**SOMETHING**]