Understanding the Multiplicity of TESS Exoplanet Host Candidates

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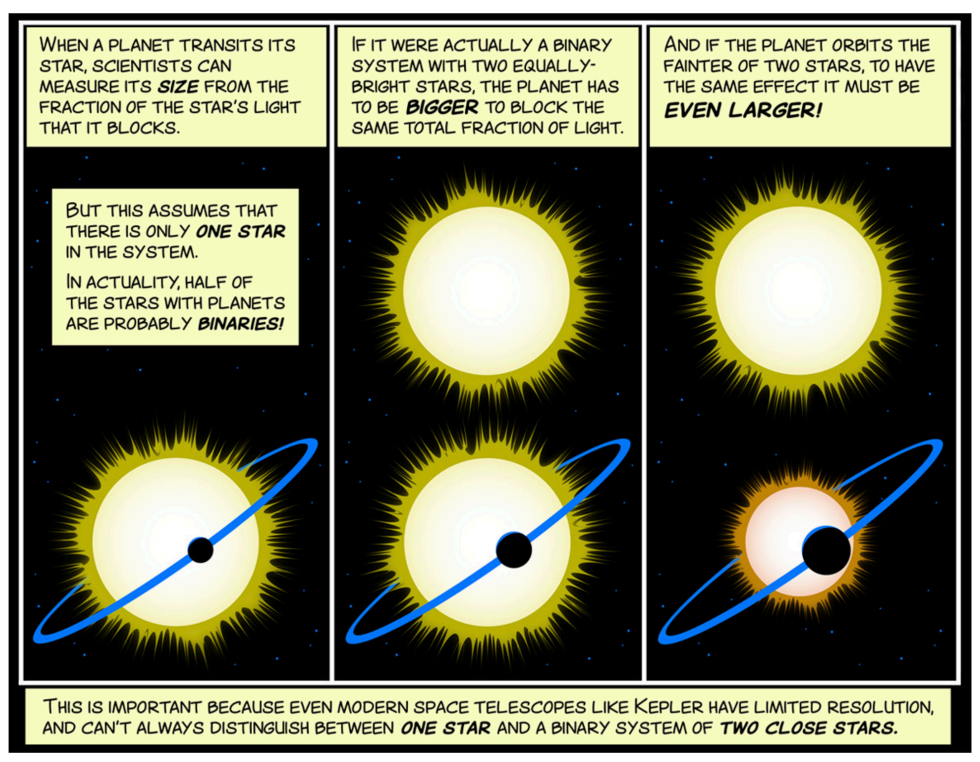
@planetarymotion

ABSTRACT

A critical aspect of exoplanet detection is the characterization of the host star that the exoplanet orbits. This includes the multiplicity of the host star, as undetected multiplicity can bias stellar and planet parameters determined from transit detection alone. To address this frequent gap in our knowledge of exoplanet hosts, we will utilize speckle interferometry to directly image approximately 500 TESS exoplanet host candidates to determine their multiplicity. Previous investigations have shown that undetected multiplicity can cause the radius of a transiting exoplanet to be underestimated, moving what were thought to be Earth-sized exoplanets into the super-Earth regime. Since 40 to 50% of exoplanet host stars reside within multiple star systems, and given the degree to which initially undetected multiplicity has skewed Kepler results, high-resolution imaging of our nearby low-mass neighbors is necessary for both accurate characterization of transiting exoplanets, as well as a better understanding of stellar astrophysics. Our investigation will expand on the speckle observations taken as a part of the POKEMON speckle survey of nearby M-dwarfs to better constrain the multiplicity of low-mass TESS exoplanet host candidates, and to constrain M-dwarf multiplicity by subtype across the entire M-dwarf sequence.

WHY DOES STELLAR MULTIPLICITY MATTER FOR TESS?



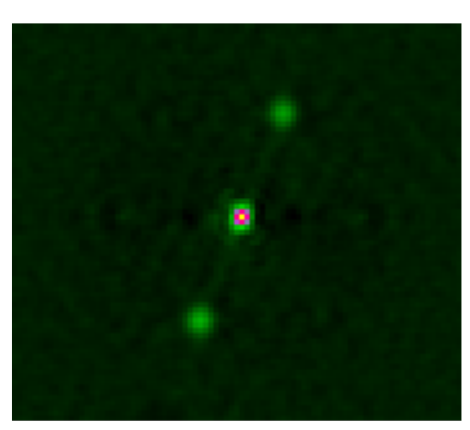
Credit: NASA/JPL - Caltech

HOW DO WE DETERMINE STELLAR MULTIPLICTY?

Example: HIP 67090 (M1V primary; 6 AU separation)

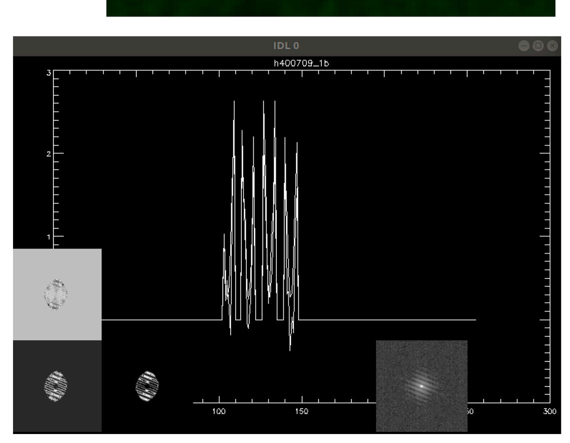
1. Observing at the DCT

Lowell Observatory's DCT is a 4.3m telescope located roughly 1 hour southeast of Flagstaff, AZ. Lowell operates the DCT in partnership with Boston U., NAU, U. Maryland, U. Toledo, and Yale U.



2. Data Reduction Pipeline

Use the main pipeline program to make reconstructed images via bispectral analysis.

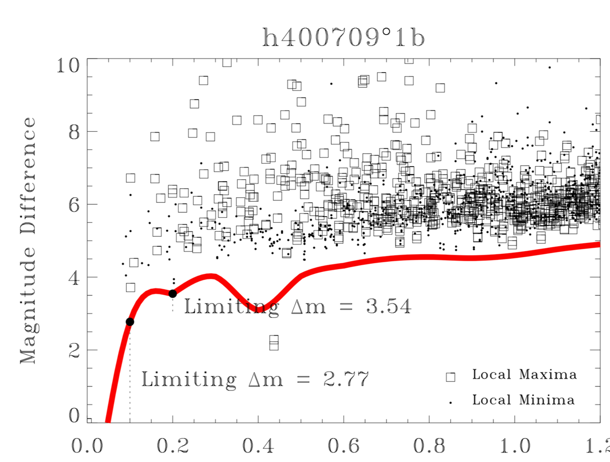


3. Visual Analysis

Visually analyze each image to determine a potential location for each binary position.

4. Analysis in the Spatial Frequency Domain

Analyze the power spectrum, the power spectrum divided by the point source, the spatial frequency fit, and the subtracted image. If there is a clear fringe pattern, then there is a binary star present.



5. Inspection of the SNR Plots

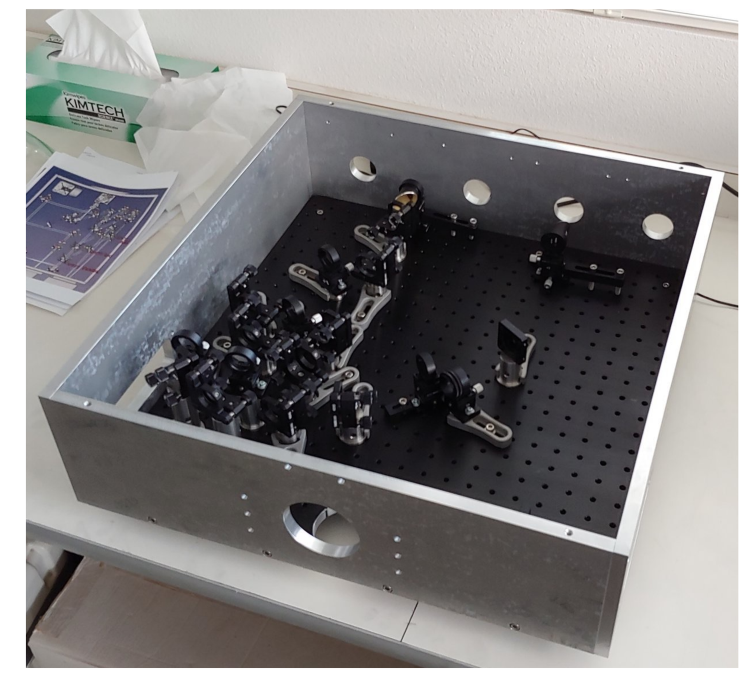
Analyze companion limits on detection or non-detection.

QWSSI

The Lowell Observatory speckle team is building a new speckle camera optimized for multiplicity measurements of low-mass stars.

The Quad-channel Wavefront-sensing Stellar Speckle Interferometer

- Observes simultaneously in six channels.
  - •577, 658, 808, and 880 nm
  - •J and H bands
- Simultaneous wavefront sensing.
  - Will provide a better understanding of the aberrations in the wavefront at that instant.
- Utilizes more of the CCD 'real estate'.
- Better optimized for the spectral features specific to low-mass stars.



THE POKEMON SPECKLE SURVEY OF NEARBY M-DWARFS

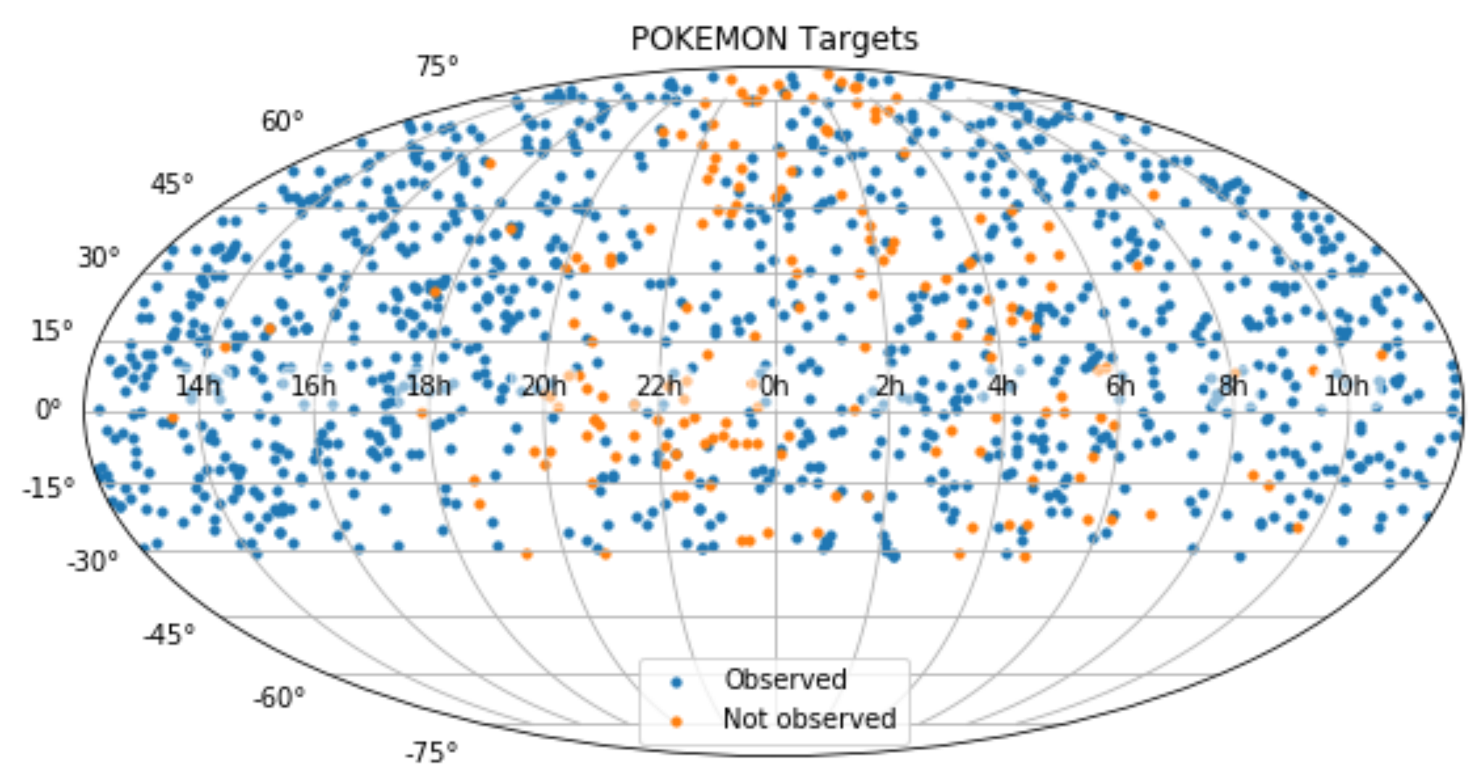
1253 Stars in the POKEMON Catalog

↓

1238 of These Stars Also in the TIC

↓

~500 Additional Stars Will Be Observed



Current status of the survey: blue symbols indicate an observed target, and orange symbols indicate targets in need of observation. Received three nights of DCT time in September to complete the POKEMON Survey.

EXPECTED RESULTS

A Refined M-dwarf Multiplicity Rate

- The POKEMON Survey is designed to be volume-limited to 15pc for spectral types as late as M9V.
  - Previous surveys have been limited to M4V because of limited aperture.
  - This survey includes additional bright targets to 25pc.
- This survey will provide sufficient statistics for determination of M-dwarf multiplicity as a function of subtype.

New Insights into Planet Formation in Multi-star Systems

- TESS has already found exoplanets orbiting within multi-star systems.
  - HD 202772Ab
    - Songhu et al. 2019
  - LTT 1445Ab
    - Winters et al. 2019
- And will find more when it moves to the north.
  - We can then compare the multiplicities of the planet-hosting and non-planet-hosting groups of low-mass stars to determine whether there is a meaningful difference between the two.

Acknowledgements

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