A Novel Method to Determine Precise Stellar Radii and Temperatures of Low Mass Stars Using JWST Transits and Occultations

The Problem
The masses, radii, and temperatures of planets depend directly on the same quantities as those of their host stars. Often the limiting factor for determining precise planetary parameters is our knowledge of their host stars. The higher the precision we can achieve measuring these stars the better we will be able to understand climates, habitability, formation, and evolution of individual stellar systems, as well as generally develop more detailed theoretical models for stellar atmospheres and evolution. This is the case for all planet hosting stars but is most apparent for low mass host stars because they are most difficult to measure. These stars, such as M-dwarfs, have been understood to be critical targets in the search for Earth-like planets.

What is an Exoplanet?
Exoplanets are planets outside of our solar system. One way we detect these planets using the transit method, which occurs when an exoplanet passes in front of its star and creates a dip in light.

Low Mass Stars
M-dwarfs are small stars that have a mass between 8% to 70% of the mass of our sun. These stars are our best hope of finding other life within the next 30 years and critical in the search for habitability. Planets like Earth are far easier to detect around small stars.

Future Applications
• **JWST**
  - The Solar System's best telescope
  - With a primary mirror size of 6.5 m (21.3 ft) and located in space, JWST’s data is far more precise and reliable
  - JWST was designed to look at atmospheres: I used the data in a way it was not originally intended

James Webb Space Telescope (JWST)

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**Findings: 3x Better Than Any Previous Result**
Notably my analysis dramatically improves the precision for $R_e$ ($3.5\%$), $T_{eff}$ ($3.3\%$), and $\rho_*$ ($4.8\%$) compared to the next best result by Cloutier et al. (2021). The improved stellar parameters propagate to improved precision in the planetary parameters, including the radius $R_e$ ($3.5\%$) and the equilibrium temperature, $T_{eq}$ ($2.5\%$), which is critical for understanding exoplanets, their climates, and habitability.

**References**
Mahajan et al., 2024, ApJ, accepted (arXiv:2402.05991) [This work]
Cloutier, et. al., 2021, AJ, 162, 174

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