Exploration of Systematic Errors in Transiting Planets and Their Host Stars

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Goal: Quantify the systematic errors in transiting exoplanet systems and in eclipsing M-dwarfs introduced by the choice of priors.

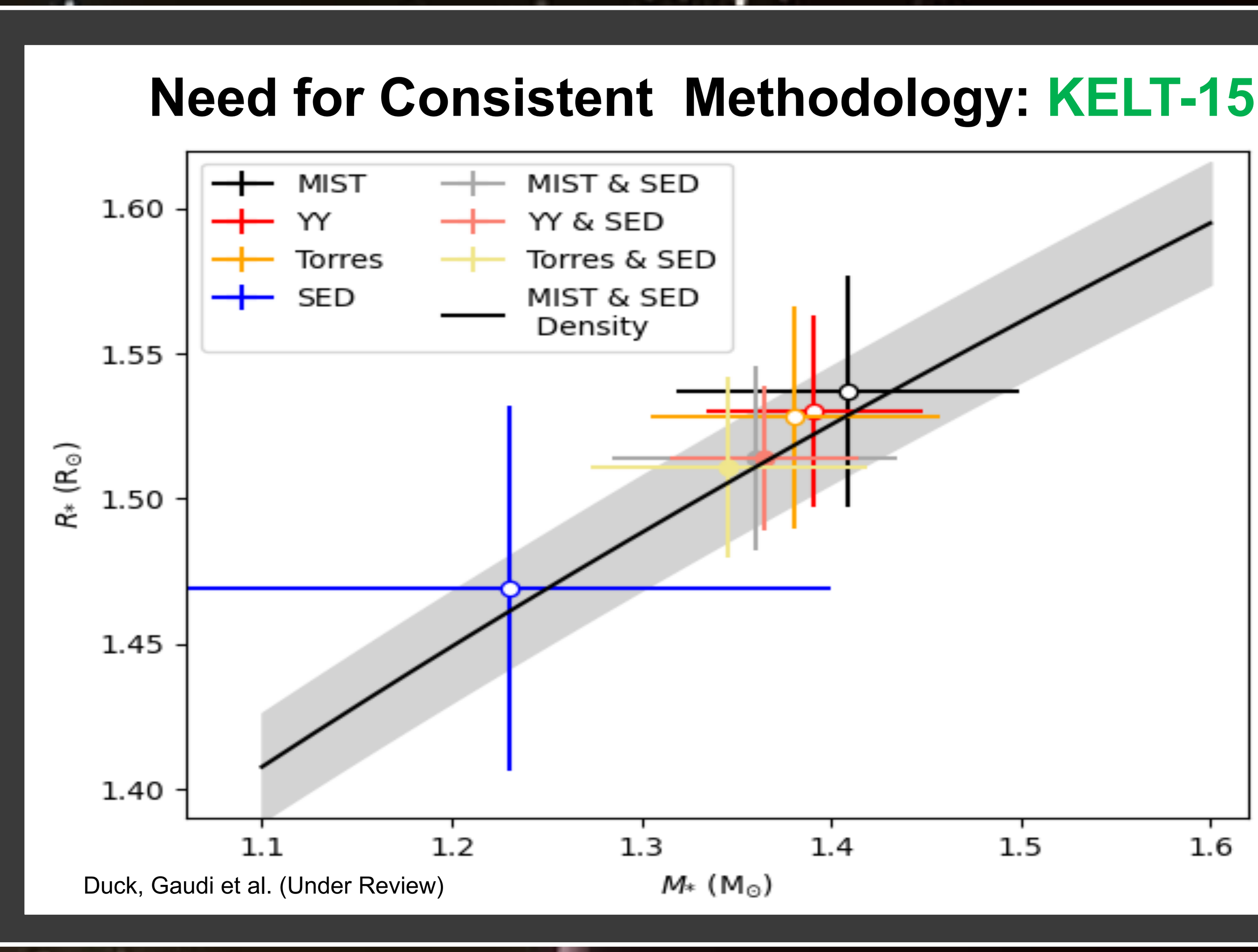
The Mass - Radius Degeneracy

$$\rho* = \frac{3\pi}{GP^2}\left(\frac{\delta^{\frac{1}{4}}}{\pi}\frac{P}{\sqrt{\tau T fwhm}}\frac{\sqrt{1-e^2}}{1+e\sin(\omega)}\right)^3$$

Seagar & Mallén-Ornelas et al. 2003

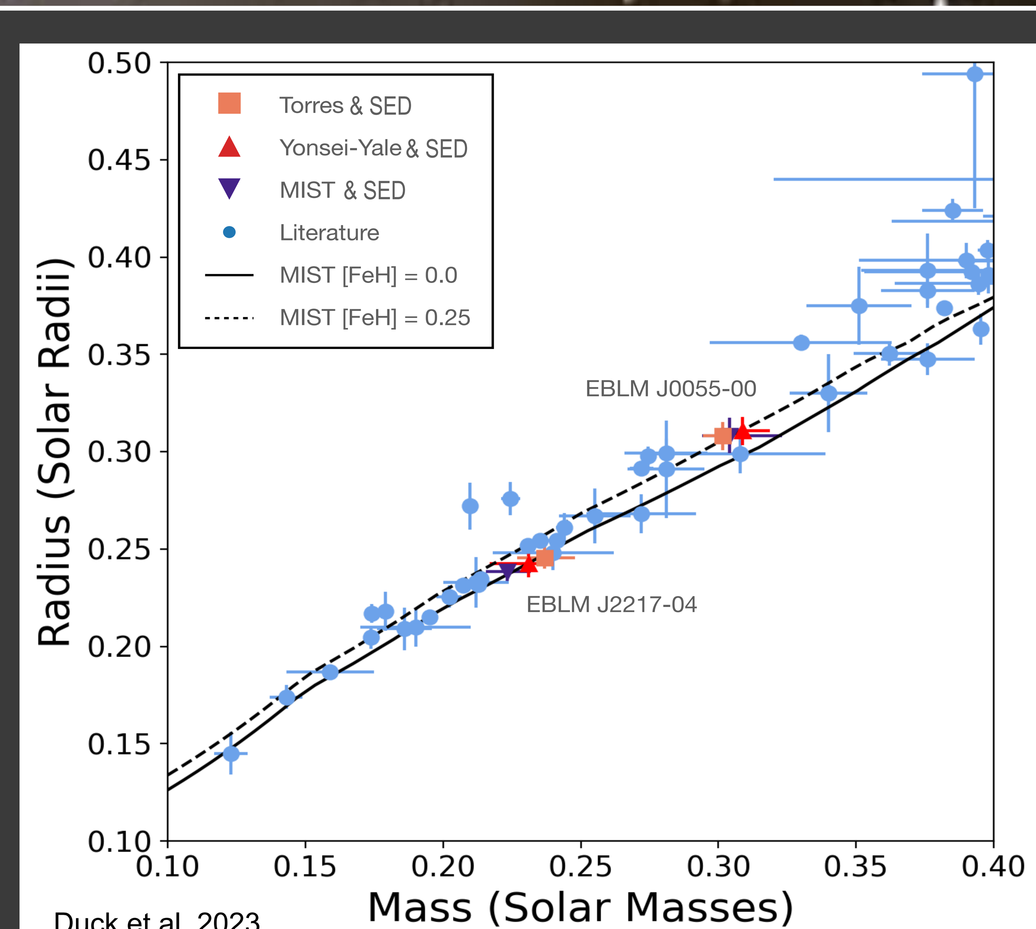
Transit and radial velocity observations can constrain the density of host stars. We investigate the systematic uncertainties, introduced by breaking this degeneracy in the stellar mass and radius, which contribute to the error budget of known planets. We also investigate the impacts on derived planet properties from imposing a prior on the stellar effective temperature, enforcing circular orbits, and applying the Claret limb darkening tables (Claret et al. 2017)

In the hot Jupiter hosting system KELT-15, we found a 1 sigma agreement in radii based on stellar characterization method and selections of priors.



Applications to transiting M-dwarfs

The Eclipsing Binaries Low Mass (EBLM; Triaud et al. 2013) project provides RV follow up for M-dwarfs transiting FGK host stars. Here, we combine these observations with K2 photometry. We can achieve precise masses, radii, and temperatures for these M-dwarfs and infer metallicities based on their host stars.



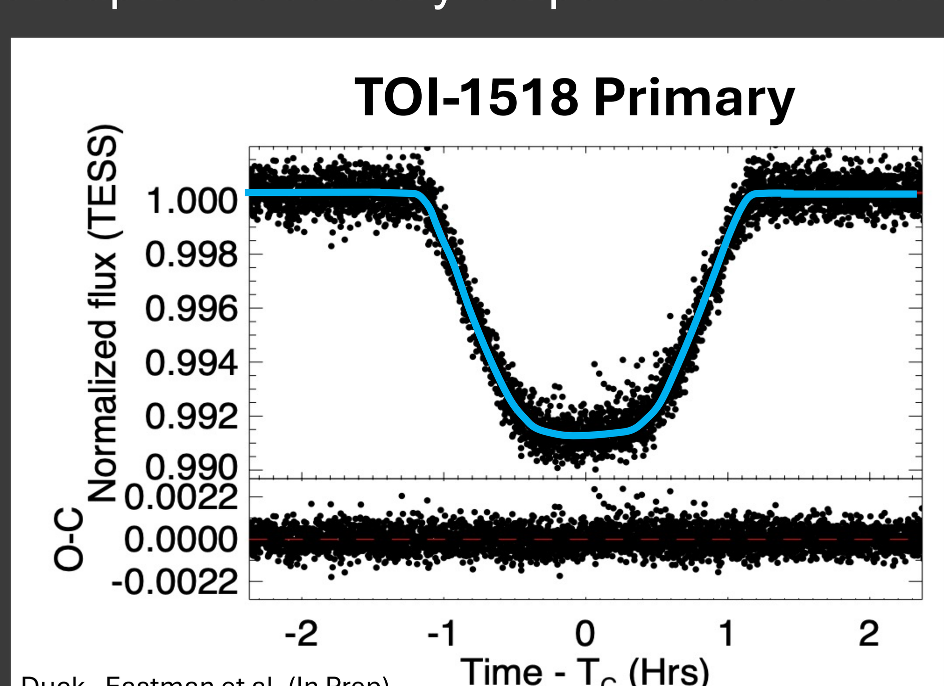
The eclipsing M-dwarfs J0055-00 and J2217-04 are now 2 of the most precisely measured in their mass regime.

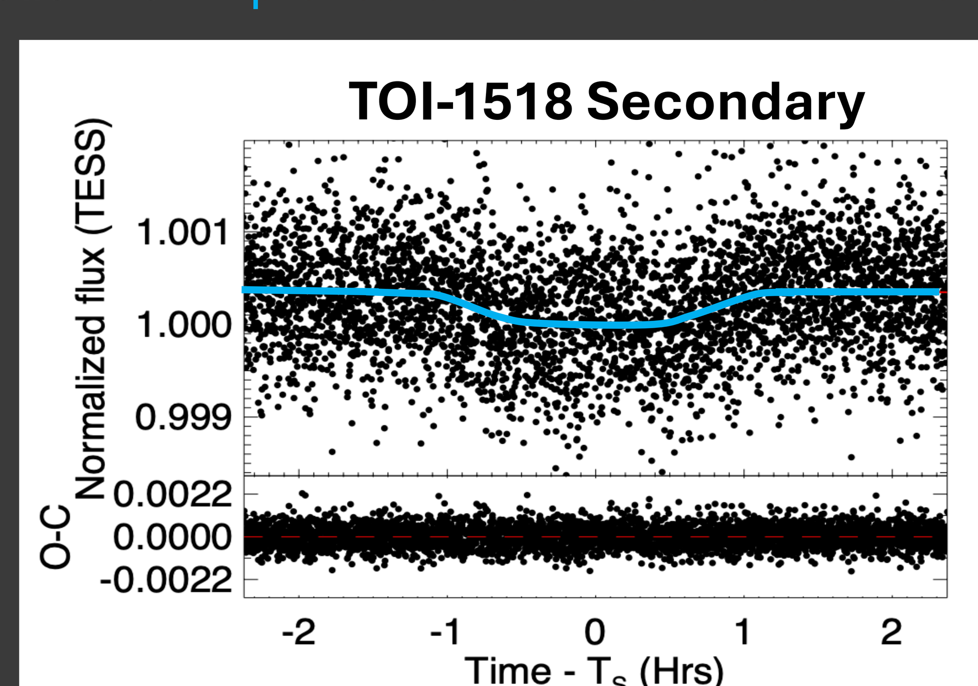
Found differences smaller than 1 sigma based on characterization technique used for the host star.

OSU undergraduate Shelby Summers will soon add another 10 eclipsing M-dwarfs to this sample

Constraints from Hot Jupiter Secondary Eclipses

Hot Jupiter secondary eclipse measurements allow for improved constraints on eccentricity.





$$\frac{a}{R_*} \propto \frac{\sqrt{1-e^2}}{1+e\sin(\omega)}$$

Reduced uncertainty in eccentricity can also improve precision in stellar density.

$$\left(\frac{\sigma_{\rho_*}}{\rho_*}\right)^2 = \left(\frac{\sigma_P}{P}\right)^2 + \left(\frac{3\sigma_{a/R_*}}{a/R_*}\right)^2$$

Eastman et al. 2023

~20 of the TESS Cycle 5 hot Jupiters could have a secondary eclipse SNR > 2

My current sample size is about 10 systems with detected secondaries

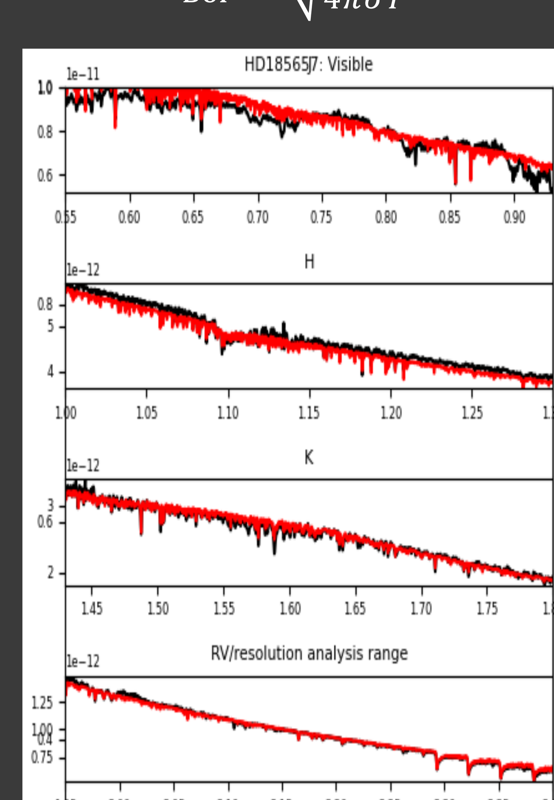
Comparing bolometric and asteroseismic stellar radii

We use high resolution spectra from UH88/SNIFS and IRTF/SpeX to bolometrically estimate the radius for ~100 LLRGB stars. Asteroseismology has also been conducted for these stars in Grunblatt et al. 2019.

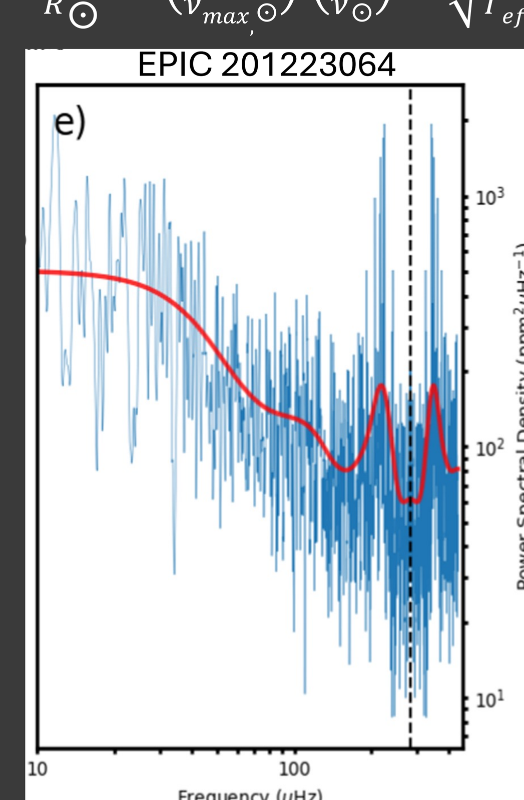
$$R_{*Bol} = \sqrt{\frac{L_*}{4\pi\sigma T^4}}$$

Stello et al. 2009b

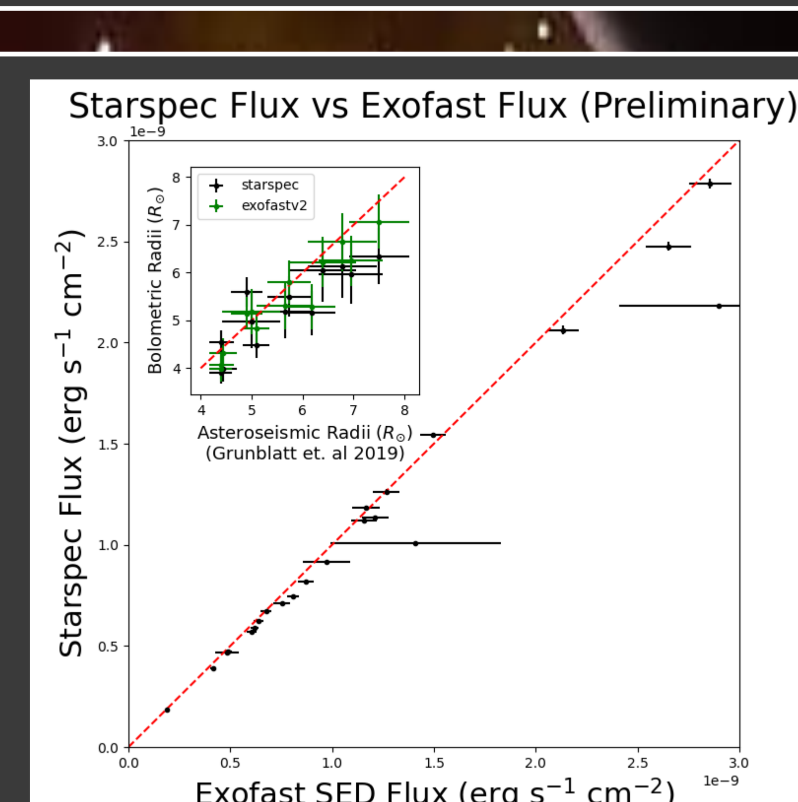
$$\frac{R_{*\nu}}{R_\odot} \simeq \left(\frac{\nu_{max}}{\nu_{max\odot}}\right)\left(\frac{\nu}{\nu_\odot}\right)^{-2}\sqrt{\frac{T_{eff}}{T_{eff\odot}}}$$



Duck, Grunblatt et al. (In Prep)



Grunblatt et al. 2019



In 3 systems, we will compare the stellar densities estimated by exoplanet transits to their asteroseismic densities