MINI-NEPTUNES AROUND M+F STARS

Studying the stellar mass - exoplanet size relationship helps us constrain how planets form and evolve, because stellar mass is a proxy for the mass available in planetary building blocks. We expect that with an increase in stellar mass (as a result of an increase in protoplanetary disk mass), that the size of planets in a system would also increase. Indeed, there are more giant planets around massive stars. However, for smaller planets this is not the case: there are fewer mini-Neptunes around more massive stars, and they are not larger in size. The relationship between stellar mass and mini-Neptune sized planets has not yet been well defined across stellar types.

Website: danayaptangco.github.io

Dana Clarice Yaptangco[1,2], Gijs Mulders[1], Harshitha Parashivamurthy[3]

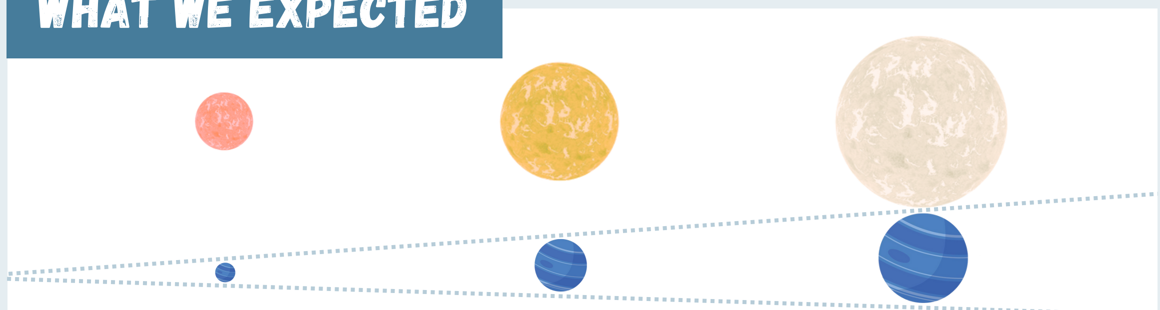
Pontificia Universidad Católica de Chile[1], Imperial College London[2], Universidad de Chile[3]

FULBRIGHT Chile

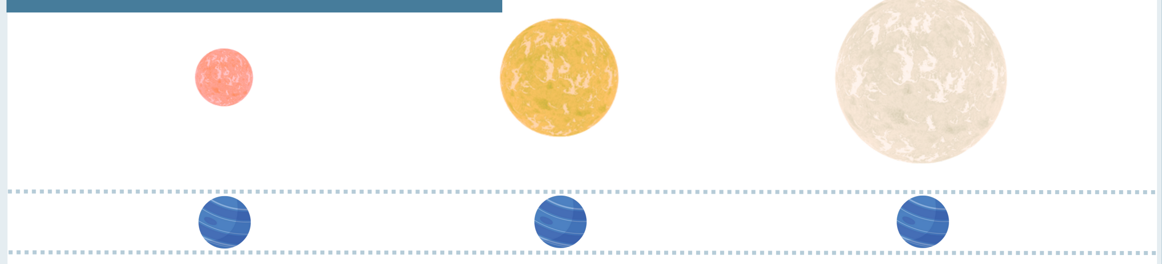
INSTITUTO DE ASTROFISICA
PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE

Imperial College London

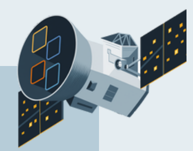
WHAT WE EXPECTED



PAST OBSERVATIONS



TESS TELESCOPE



Previously, using observations from NASA's Kepler Telescope (2009-2018), it appeared as though the size of mini-Neptune planets stays the same regardless of spectral host type across FGKM stars.[1]

Now, using NASA's **Transiting Exoplanet Satellite Survey (TESS)** launched in 2018, we are able to observe planets around **cooler M dwarf stars** and **hotter F type stars**, as shown in **Figure 1**, to get a clearer picture on the **expected stellar dependence.**[2]

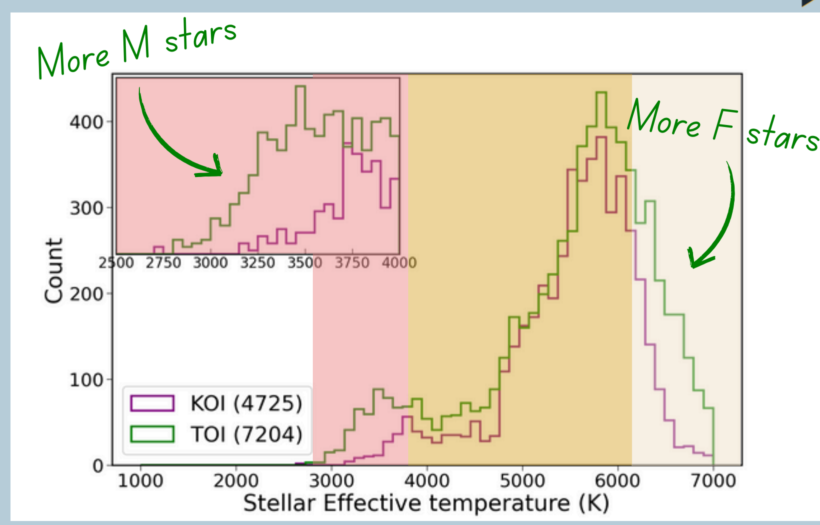


Figure 1.[2] TOI = TESS Object of Interest (planet candidate)
KOI = Kepler Object of Interest (planet candidate)

RESULTS

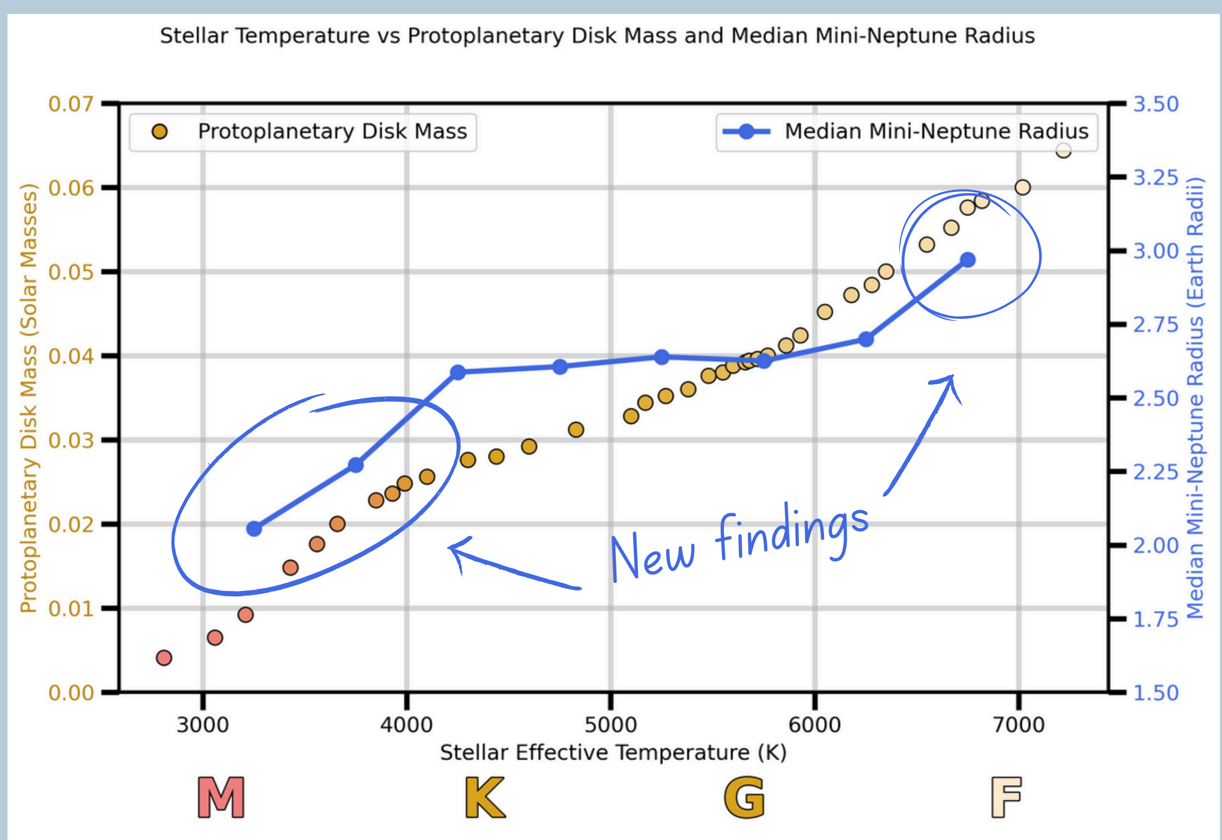


Figure 2.

COMPLETENESS

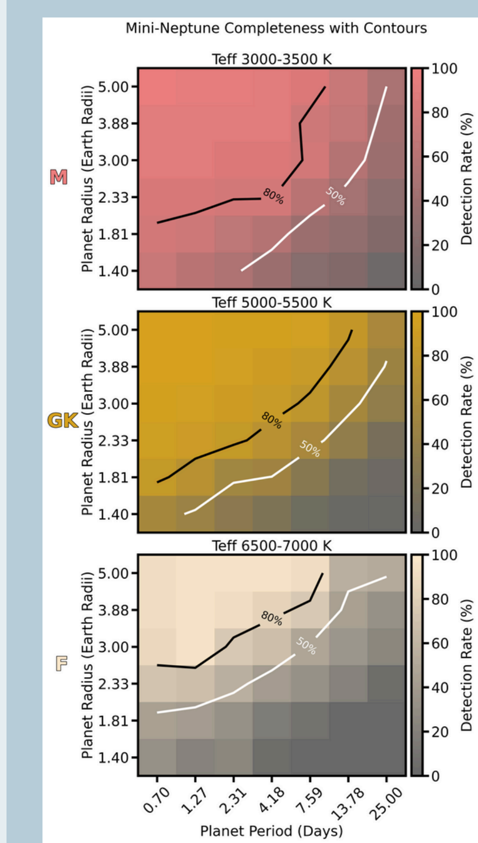


Figure 3.

CORRECTION EFFECTS

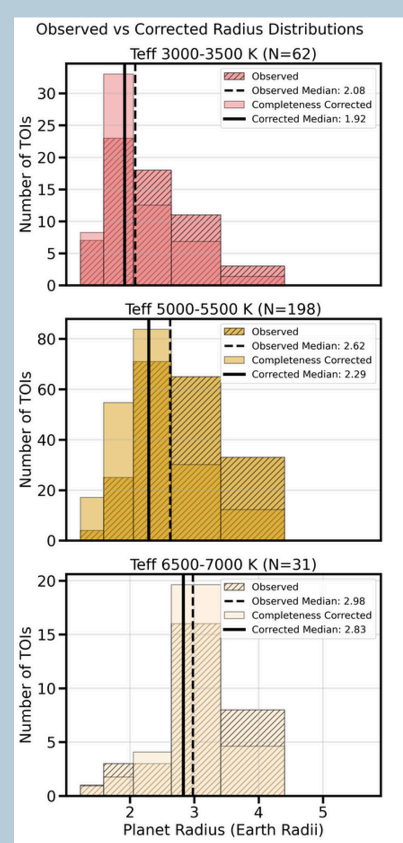


Figure 4.

METHODS

To probe the stellar mass dependence of mini-Neptunes, we used the **NASA Exoplanet Archive** and analyzed the existing **TESS Objects of Interest (TOI)** list, which host **planet candidates**. <u>We found that cool M dwarf stars host smaller planets and that hotter F stars host larger planets</u> (**Figure 2**).

However, this list likely contains **biases in planet size** due to the fact that smaller planets are harder to detect around larger stars, so we control for that.

To account for **detection bias** effects, we generated a **representative sample** of ~1000 stars *without planets* that have the same range of Effective Temperature, Magnitude, and Stellar Radius as the TOIs which host planet candidates.

Using this sample, we ran a thorough **injection-and-recovery** test to obtain the **completeness** of mini-Neptune detections for FGKM stars (**Figure 3**).

After calculating transit probability and applying the completeness **correction effects** (**Figure 4**), we found that **detection bias does not meaningfully impact our results** that planet size scales with stellar size.

CONCLUSION

Unlike findings that used the Kepler exoplanet survey, we find that **there is a correlation between spectral type and the radii of the exoplanets they host** using TESS, specifically of mini-Neptunes.

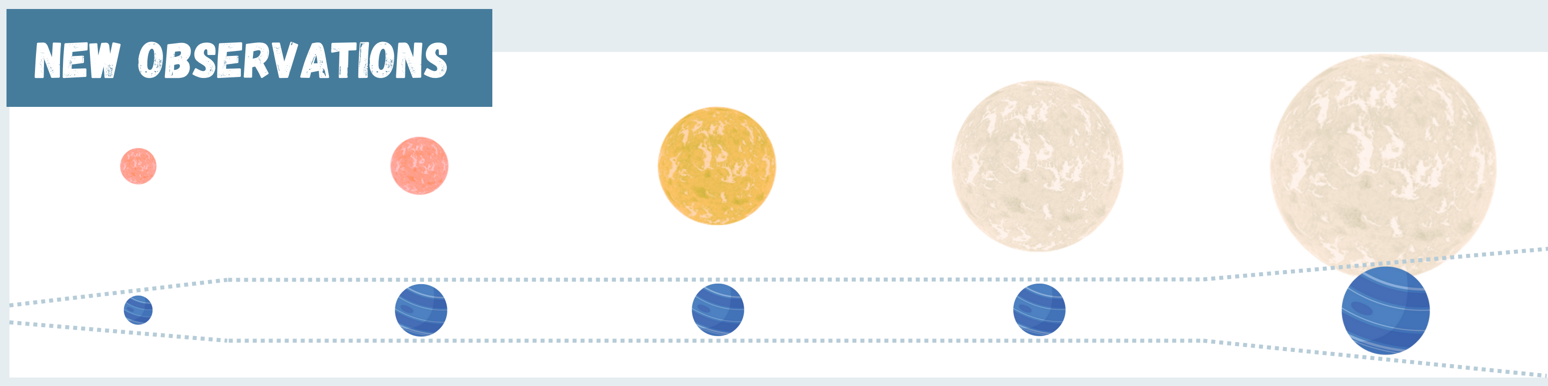
This finding was only **possible with** new data made available by **TESS**, because in the G-K star range, as observed with Kepler, the radii of mini-Neptunes do not vary meaningfully. This indicates that it is **necessary to go to extremes** of late M dwarfs and F-A stars in order to probe the stellar dependencies of planet size.

PLANET FORMATION IMPLICATIONS

These results support the idea that there is a stellar mass dependence of mini-Neptune size, but that there is **another mechanism** that operates mainly in **G-K stars** that "hides" this dependence.

This **may be atmospheric mass loss**, which gets stronger for more massive stars, causing an anti-correlation between planet size and stellar mass, which could be operating simultaneously to create this result.

NEW OBSERVATIONS



References
[1] Mulders, G., Pascucci, I., & Apai, D. (2015). An increase in the mass of planetary systems around lower-mass stars. The Astrophysical Journal, 814(2), 130.
[2] Parashivamurthy, H., & Mulders, G. (2025). Radius valley scaling among low mass stars with TESS. arXiv:2507.07181.