Giant Planets Transiting Giant Stars with TESS

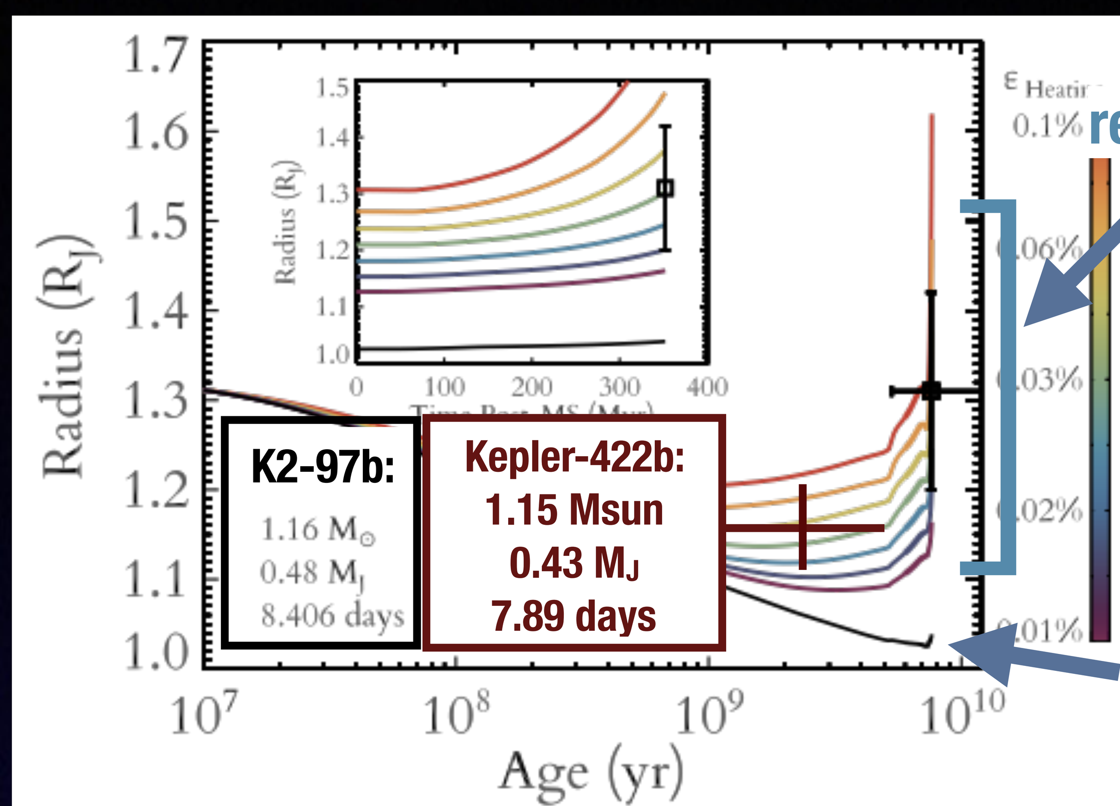
Samuel K. Grunblatt[1,2,3], Daniel Huber[1], Eric Gaidos[1], Ashley Chontos[1]

1. Institute for Astronomy, University of Hawai'i, Honolulu, Hawaii
2. Department of Astrophysics, American Museum of Natural History, New York, NY
3. Center for Computational Astrophysics, Flatiron Institute, New York, NY

www.ifa.hawaii.edu/users/skg

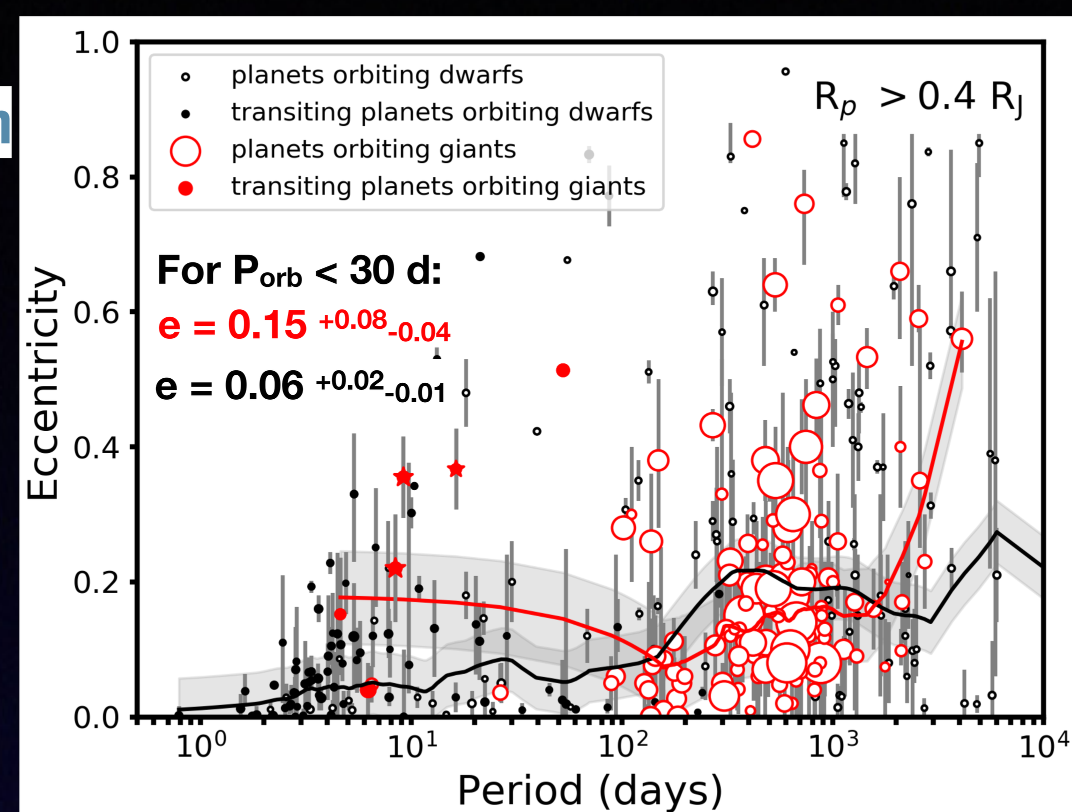
What did we know about giant planets transiting giant stars before TESS?

1) Stellar evolution from the main sequence to the giant phase can re-inflate warm Jupiters.



Lopez & Fortney (2016), Grunblatt+(2016), Grunblatt+ (2017)

2) Transiting giant planets seem to prefer moderately eccentric orbits around evolved stars.



Villaver+ (2014), Grunblatt+ (2018)

3) Warm/hot Jupiters are roughly equally common around main sequence and low luminosity red giant branch (LLRGB,3-8R_{Sun}) stars.

TABLE 3
COMPARISON OF PLANET OCCURRENCE AROUND MAIN SEQUENCE AND EVOLVED STARS

Planet Radius	Planet Sample	Stellar Sample	Planet Period 3.5-10 days	10-29 days	29-50 days
1-2 R_J	Main Sequence	Main Sequence	0.15 ± 0.06	0.12 ± 0.05	0.38 ± 0.09
	Main Sequence	LLRGB	0.28 ± 0.16	0.27 ± 0.16	*
	LLRGB	LLRGB	0.49 ± 0.28	$<0.33^{+0.07}_{-0.12}$	$<6.8^{+1.7*}_{-4.6}$
	LLRGB (<6 $R_\odot$)	LLRGB (<6 $R_\odot$)	0.72 ± 0.41	$<0.46^{+0.10}_{-0.26}$	$<10.2^{+1.8*}_{-8.2}$
0.5-1 R_J	Main Sequence	Main Sequence	0.32 ± 0.13	0.70 ± 0.20	0.48 ± 0.11
	Main Sequence	LLRGB	0.27 ± 0.12	0.35 ± 0.04*	*
	LLRGB	LLRGB	$<0.23^{+0.02}_{-0.01}$	$<0.73^{+0.09*}_{-0.16}$	$<22.2^{+15.4*}_{-17.2}$
	LLRGB (<6 $R_\odot$)	LLRGB (<6 $R_\odot$)	<0.28 ± 0.11	$<0.86^{+0.30*}_{-0.46}$	$<24.0^{+5.1*}_{-20.3}$
0.2-0.5 R_J	Main Sequence	Main Sequence	0.93 ± 0.13	2.83 ± 0.29	1.85 ± 0.41
	Main Sequence	LLRGB	23.4 ± 16.6*	*	*
	LLRGB	LLRGB	<1.9±0.4*	<62.8*	*
	LLRGB (<6 $R_\odot$)	LLRGB (<6 $R_\odot$)	$<2.2^{+0.5*}_{-1.1}$	<72.9*	*

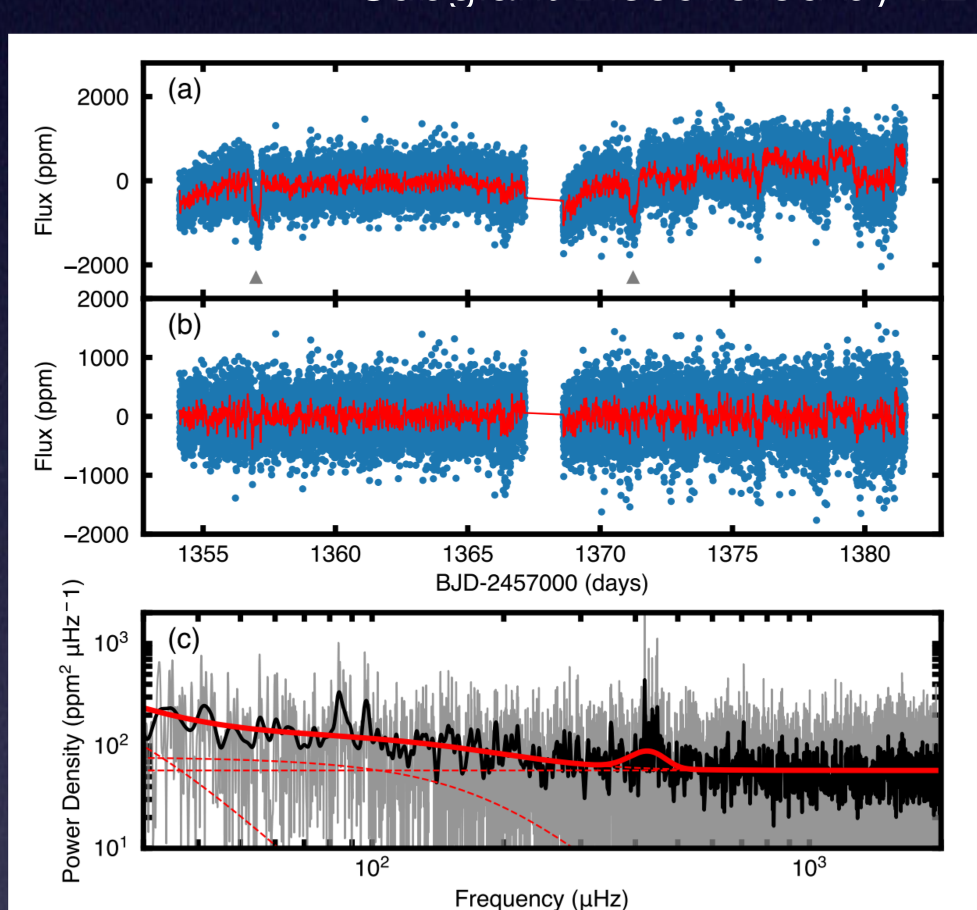
NOTE. — All occurrence values quoted are percentages. Main sequence planets orbiting main sequence star results are taken from Howard et al. (2012).

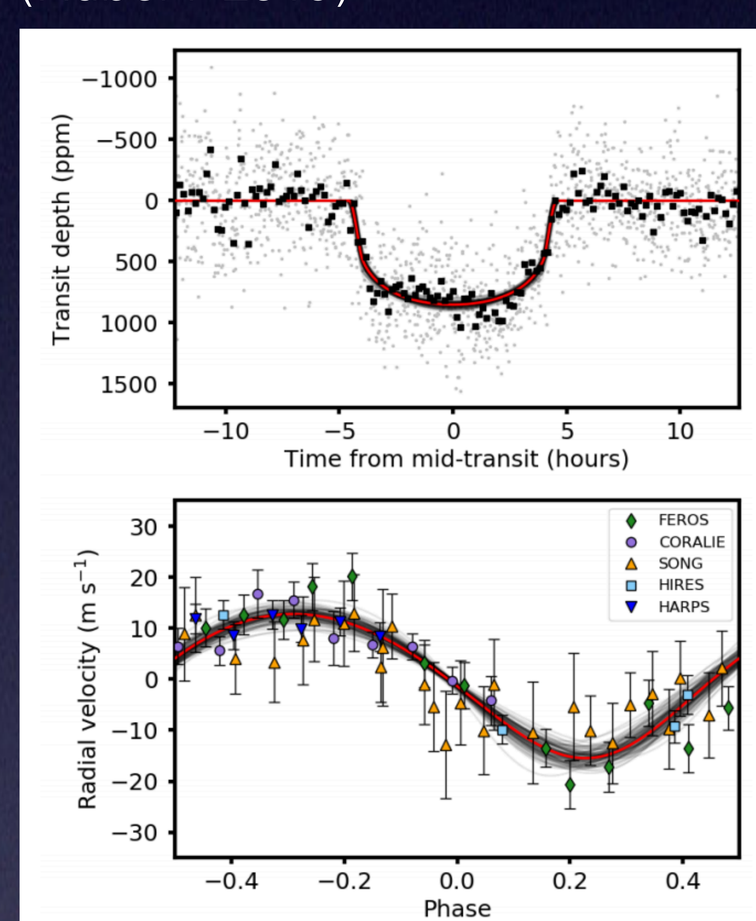
* Injection/recovery tests indicate a completeness below 50% for these regimes. No value is reported in those regimes where no injected signal was recovered.

Grunblatt+ (in review.)

What have we learned from TESS about giant planets transiting giant stars so far?

TOI-197: A Hot Saturn Orbiting an Oscillating Late Subgiant Discovered by TESS (Huber+ 2019)

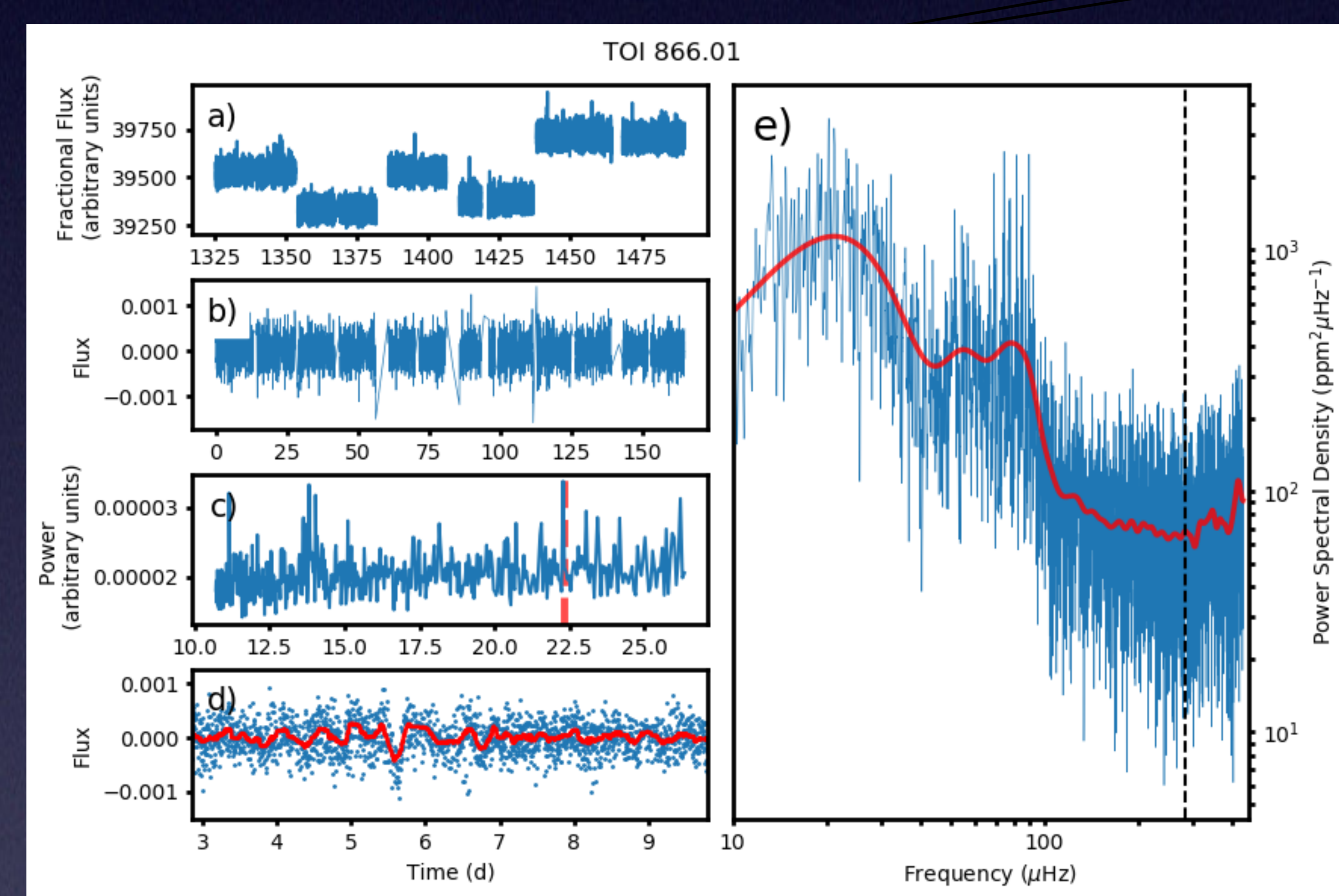




P_{orb}=14.276d, R_p = 0.835 +/- 0.03 R_J, M_p = 0.200 +/- 0.02 M_J,
R_S = 2.94 +/- 0.06 R_{Sun}, M_S = 1.21 +/- 0.07 M_{Sun}

Though technically not a giant star, TOI-197 is similar to the typical giant star systems expected from TESS. The precise constraint on **stellar and planet density** allows a **direct test of planet inflation and evolution scenarios**.

TOI-866: The First TESS Object of Interest Identified Around a Giant Star



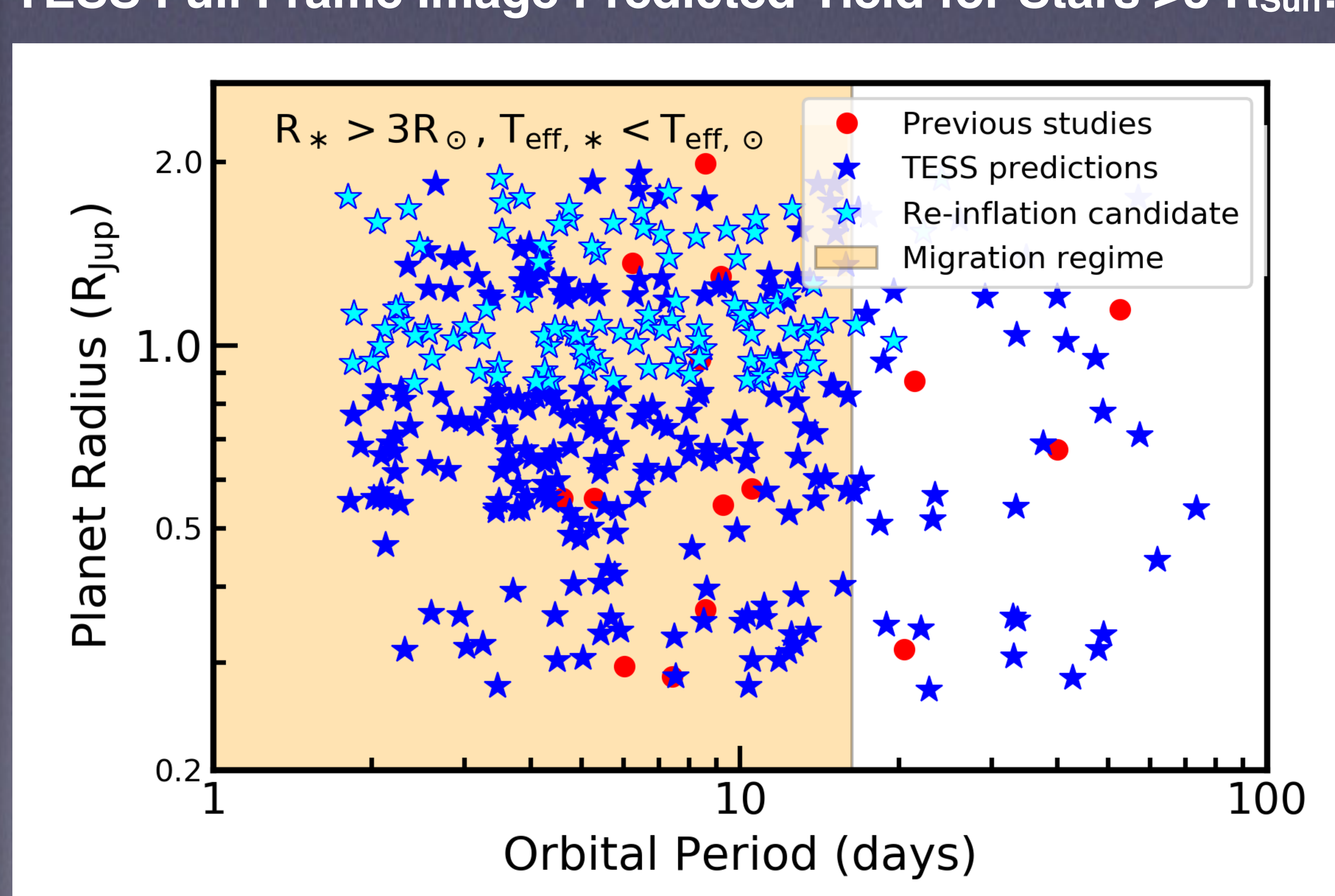
If confirmed, TOI-866 would be the **largest star to host a transiting planet discovered to date.** This would make TOI-866 a benchmark for understanding the late stage survival and evolution of gas giant planets!

P_{orb}=22.339d, R_p = 1.877 +/- 0.24 R_J
R_S = 8.04 +/- 1.08 R_{Sun}, M_S = 1.48 +/- 0.32 M_{Sun}

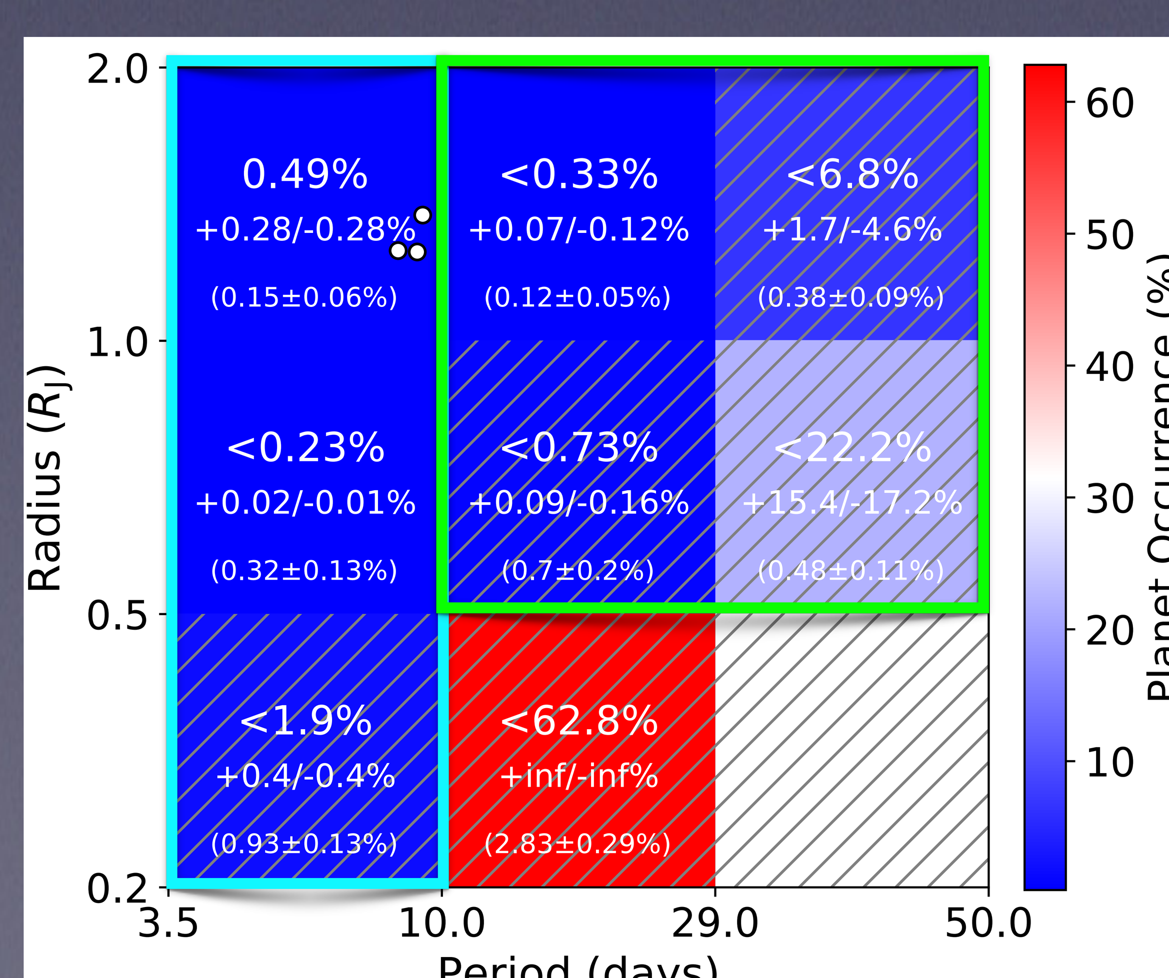
What will TESS teach us about giant planets transiting giant stars in the future?

TESS is predicted to find hundreds of more planet candidates in the Full Frame Image data, exploration of which has only just begun!

TESS Full Frame Image Predicted Yield for Stars >3 R_{Sun}:



TESS will reveal the dependence of planet inflation, migration, and inspiral as a function of stellar mass and evolutionary stage.



LLRGB occurrence rate: center of box
MS occurrence rate: bottom of box (in parentheses)
dashed gray lines: injection/recovery completeness <50% (unreliable)

- Full sky coverage of TESS—more opportunities for short-period, small planet detections
- CVZs: more opportunities for longer-period planet detections, enhancing completeness of this plot

Future efforts

1. Compare detection of giant star TOIs in 2-minute cadence data to FFI, 30-minute cadence data detection.
2. Perform systematic search of bright giants in FFI data with TASOC lightcurves
3. Search all giant stars in FFIs where oscillations can be detected!

Interested in getting involved?

Email me: skg3@hawaii.edu
@ me on Twitter: skgrunblatt

Or find me here this week!