

Asteroseismology of Exoplanet-Host Stars with *TESS*

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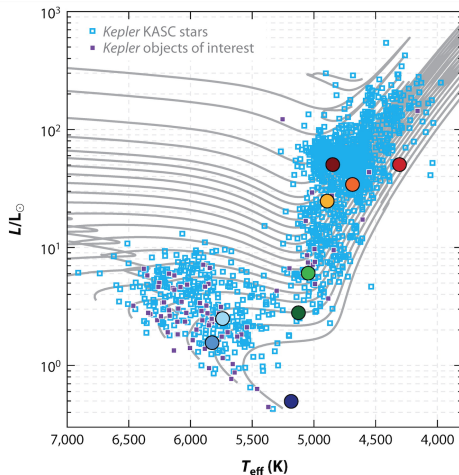
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Solar-like oscillations and the *Kepler* legacy

- Cool-star asteroseismology with *Kepler*:
 - Several hundred solar-type stars
 - Over 10,000 red giants
- ~ 100 KOIs with detected solar-like oscillations



Chaplin & Miglio (2013)

Synergy between asteroseismology and exoplanetology

- Precise characterisation of host stars
 - 1.2 % precision in R , 3.3 % in M and 14 % in age for third of asteroseismic KOI sample (Silva Aguirre et al. 2015)
 - Kepler-444: oldest known system of terrestrial-size planets (Campante et al. 2015)
- Spin-orbit alignment of exoplanet systems
 - Kepler-56: first misaligned multiple-planet system (Huber et al. 2013)
 - Ensemble analysis (Campante et al. 2016)
- Orbital eccentricity determination via asterodensity profiling
 - Small planets in *Kepler* multis have low eccentricities (Van Eylen & Albrecht 2015)

Synergy between asteroseismology and exoplanetology

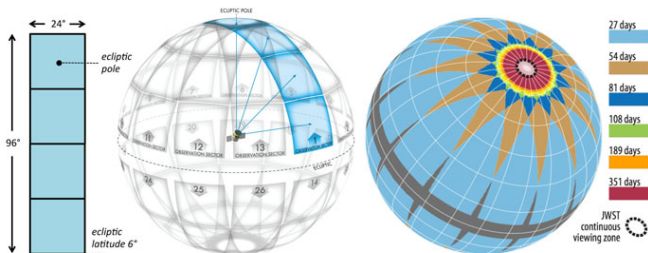
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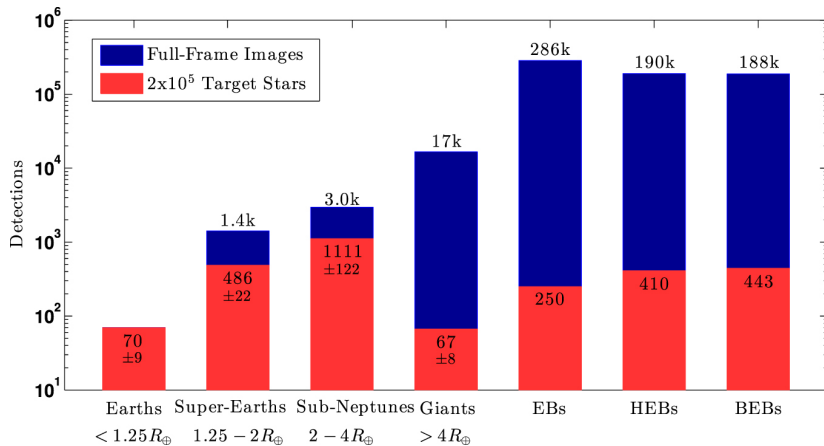
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Overview of *TESS*

- December 2017 launch
- All-sky survey (FOV shown below)
- Stars observed for at least 27 days
- 2-min cadence ($\sim 2 \times 10^5$ pre-selected FGKM dwarfs)
- 30-min cadence (full-frame images)



Expected *TESS* planet yield

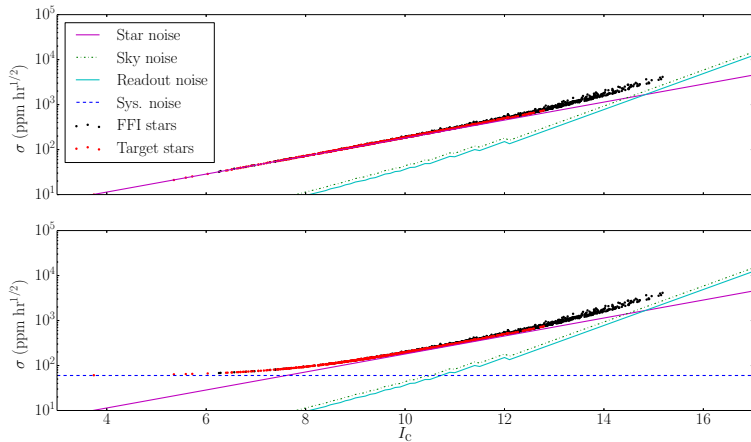


Sullivan et al. (2015)

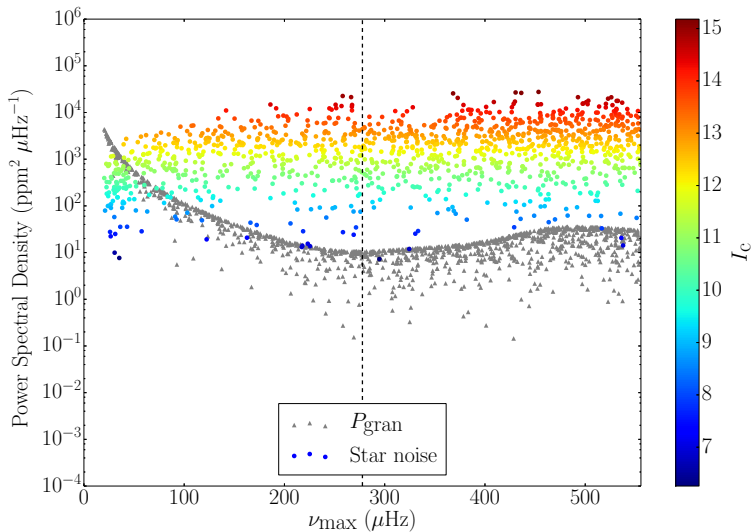
Predicting the detectability of oscillations with *TESS*

- Excellent photometric precision will enable asteroseismology of solar-type and red-giant stars
- Detection test:
 - Sets detection threshold for excess power due to oscillations
 - Works in frequency domain
 - 5 % false alarm probability
 - Validated using *Kepler* data and adapted to *TESS* specifications

TESS photometric noise model

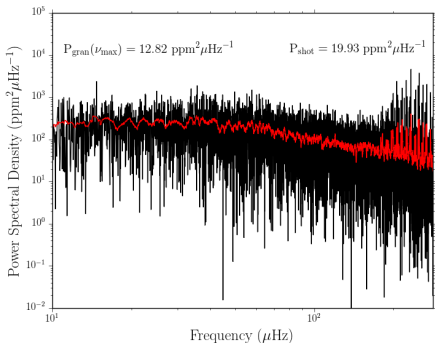


Background power spectral density

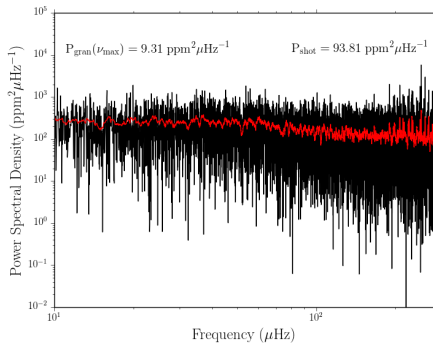


Kepler-56 as seen by *Kepler* and *TESS*

Kepler



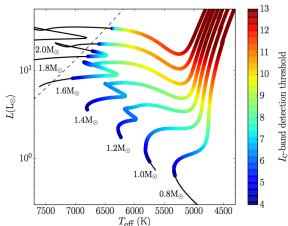
TESS



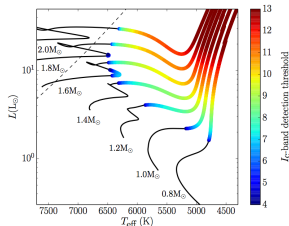
Figures courtesy of James Kuszlewicz

Detectability of oscillations across the HR diagram

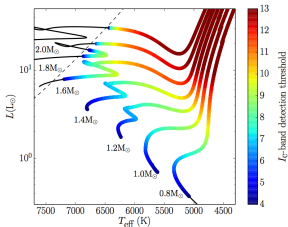
TESS 2-min cadence (target stars)



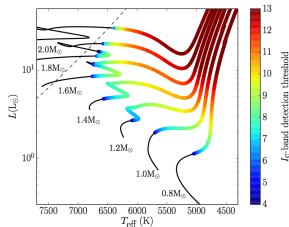
(a) $T = 27$ d, $\sigma_{\text{sys}} = 0$ ppm hr^{1/2}.



(b) $T = 27$ d, $\sigma_{\text{sys}} = 60$ ppm hr^{1/2}.



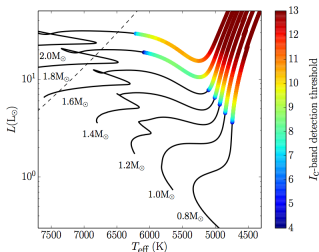
(c) $T = 351$ d, $\sigma_{\text{sys}} = 0$ ppm hr^{1/2}.



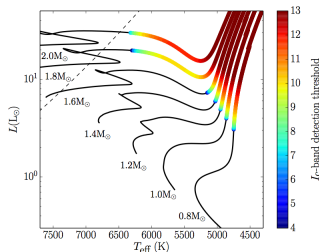
(d) $T = 351$ d, $\sigma_{\text{sys}} = 60$ ppm hr^{1/2}.

Detectability of oscillations across the HR diagram

TESS 30-min cadence ('full-frame image' or FFI stars)



(a) $T = 27$ d, $\sigma_{\text{sys}} = 60 \text{ ppm hr}^{1/2}$.



(b) $T = 351$ d, $\sigma_{\text{sys}} = 60 \text{ ppm hr}^{1/2}$.

Overall *TESS* asteroseismic yield

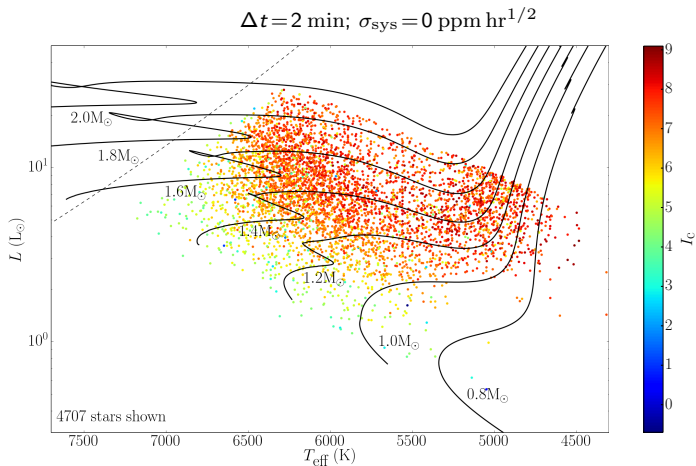
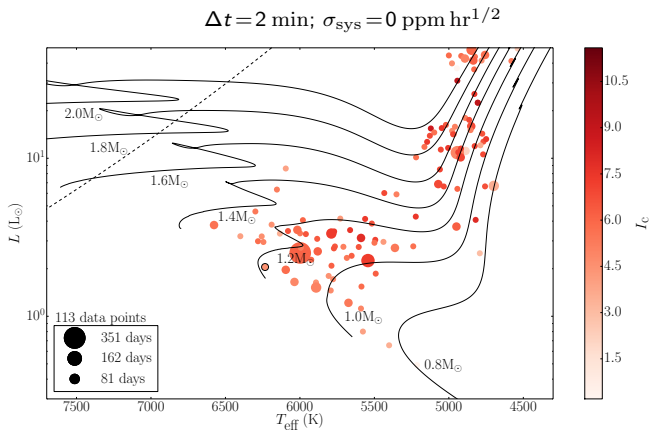


Figure courtesy of Mat Schofield (go and see his poster!)

- There are three separate contributions to this yield:
 - Previously known hosts (transiting or not)
 - *TESS* target hosts (2-min cadence)
 - *TESS* FFI hosts (30-min cadence)

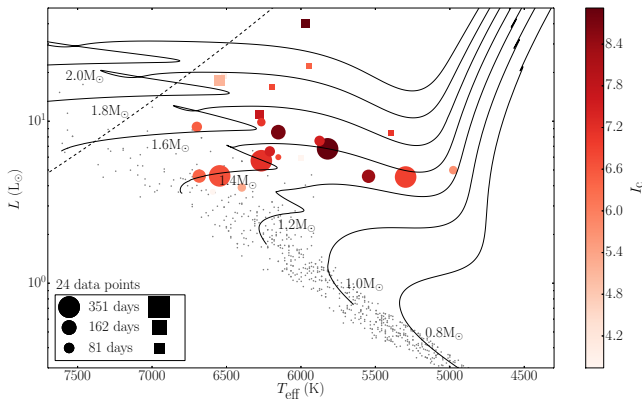
Asteroseismic yield of known exoplanet-host stars



Asteroseismic yield of *TESS* target hosts

Based on synthetic target-host population of Sullivan et al. (2015)

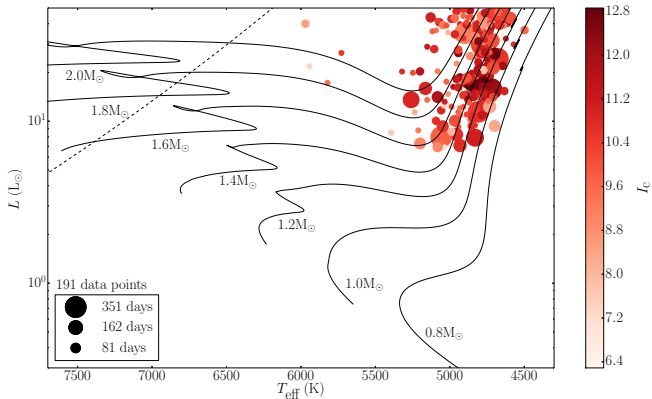
($\Delta t = 2$ min; $\sigma_{\text{sys}} = 0$ ppm hr $^{1/2}$)



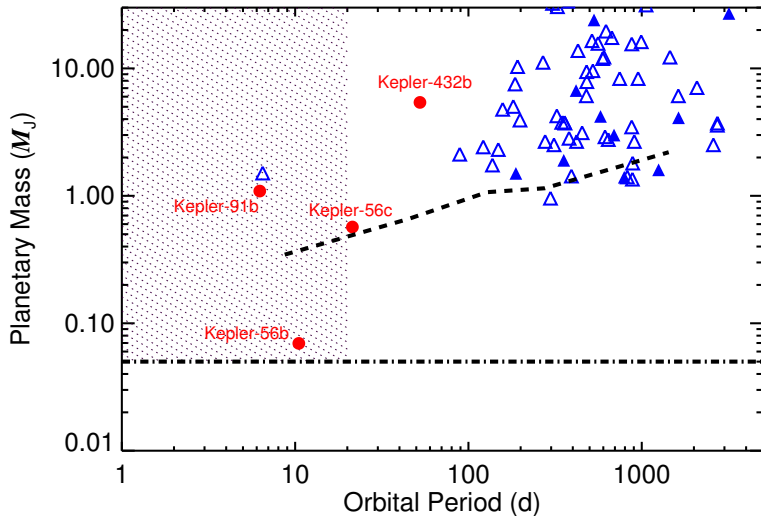
Asteroseismic yield of *TESS* FFI hosts

Based on synthetic FFI-host population of Sullivan et al. (2015)

($\Delta t = 30$ min; $\sigma_{\text{sys}} = 0$ ppm hr $^{1/2}$)



Asteroseismology of red-giant hosts with *TESS*



- Asteroseismic yield of known exoplanet-host stars
 - Over 100 known hosts with detections
 - Link to ESA's *CHEOPS*
- Asteroseismic yield of *TESS* target hosts
 - Few dozen *TESS* target hosts (mainly F dwarfs and subgiants)
- Asteroseismic yield of *TESS* FFI hosts
 - Up to 200 red-giant hosts spanning a range of masses
- Results to be presented in Campante et al. (submitted to ApJ)

⇒ Threefold improvement relative to *Kepler*!