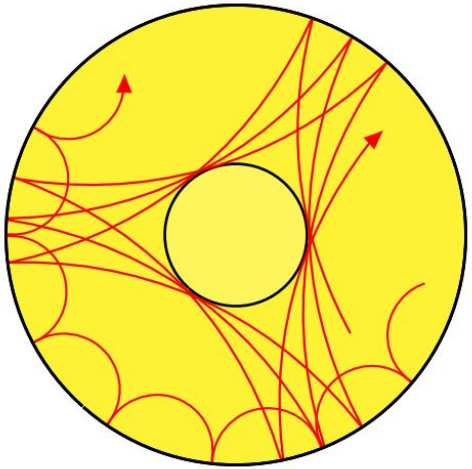
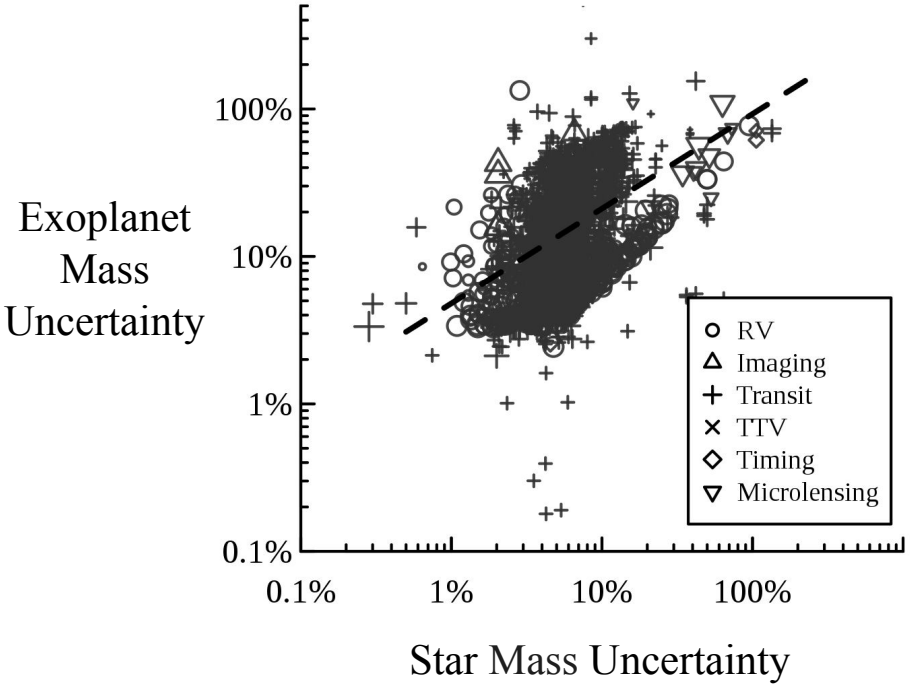
Fundamental Parameters of Exoplanet Host Stars with Asteroseismology

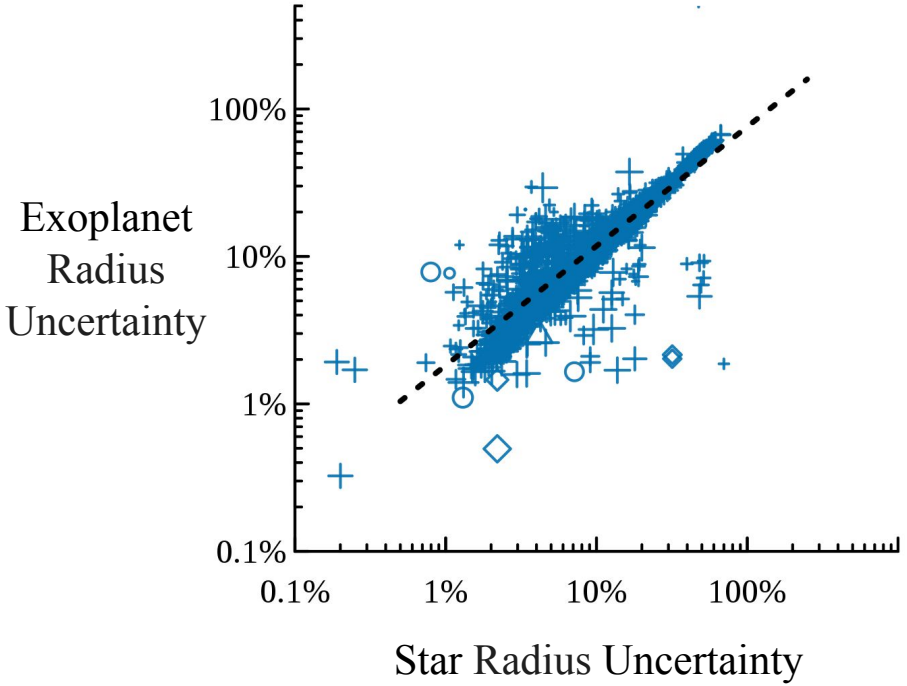


Earl Bellinger
ERES-III, June 12, 2017
SAGE Group, Max Planck Institute for Solar System Research, Germany
Department of Astronomy, Yale University

STELLAR AGES
SAGE
GALACTIC EVOLUTION

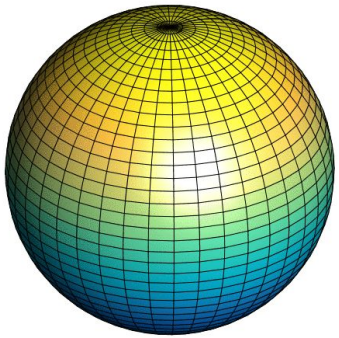
Planetary Parameters Depend on Stellar Parameters



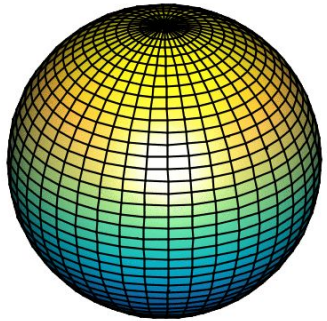


Solar-like Oscillations

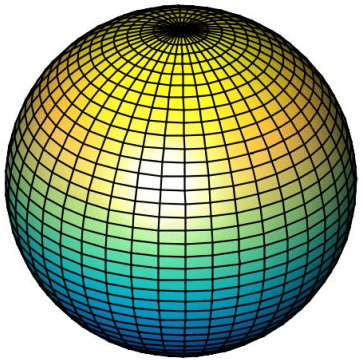
"...velocity fields in the solar atmosphere have been detected and measured..."



ℓ=1
dipole

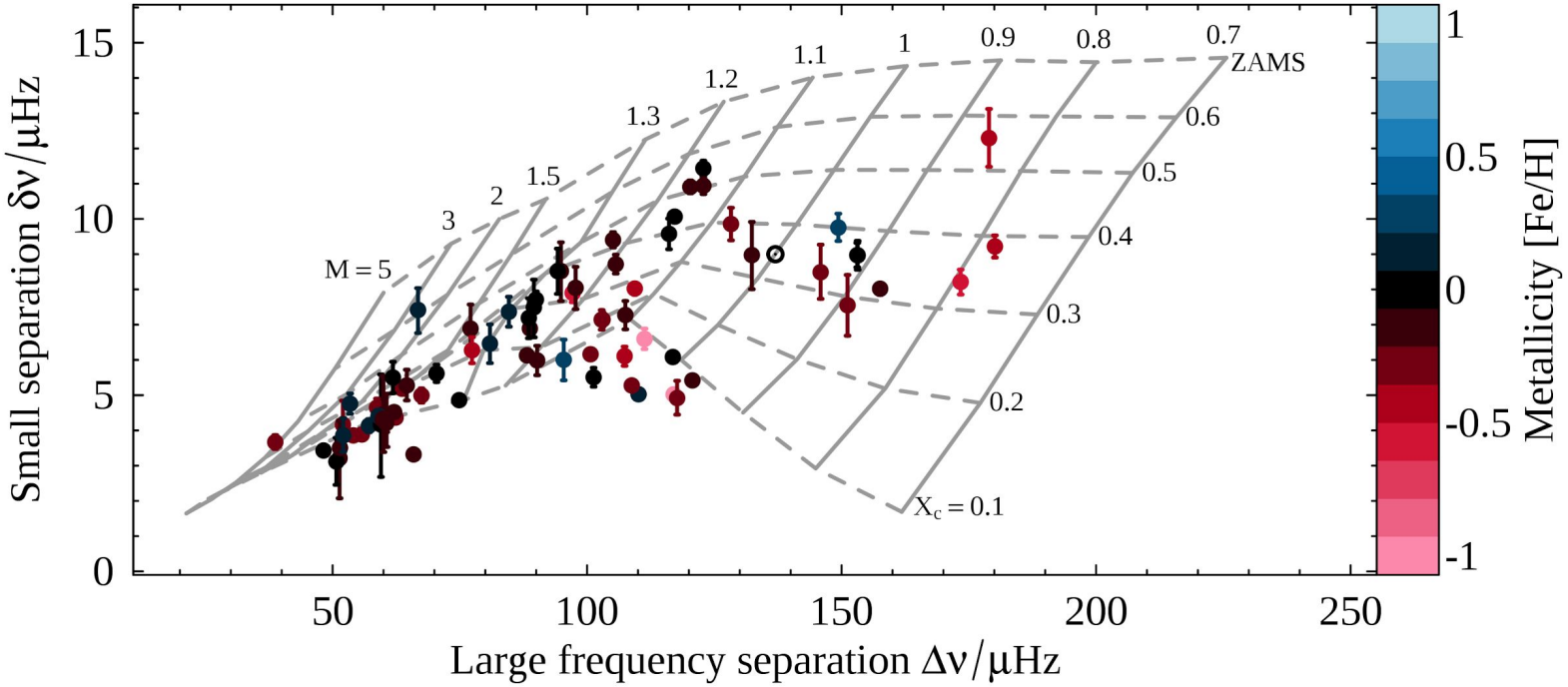


ℓ=2
quadrupole



ℓ=3
octupole

The “Asteroseismic HR” Diagram



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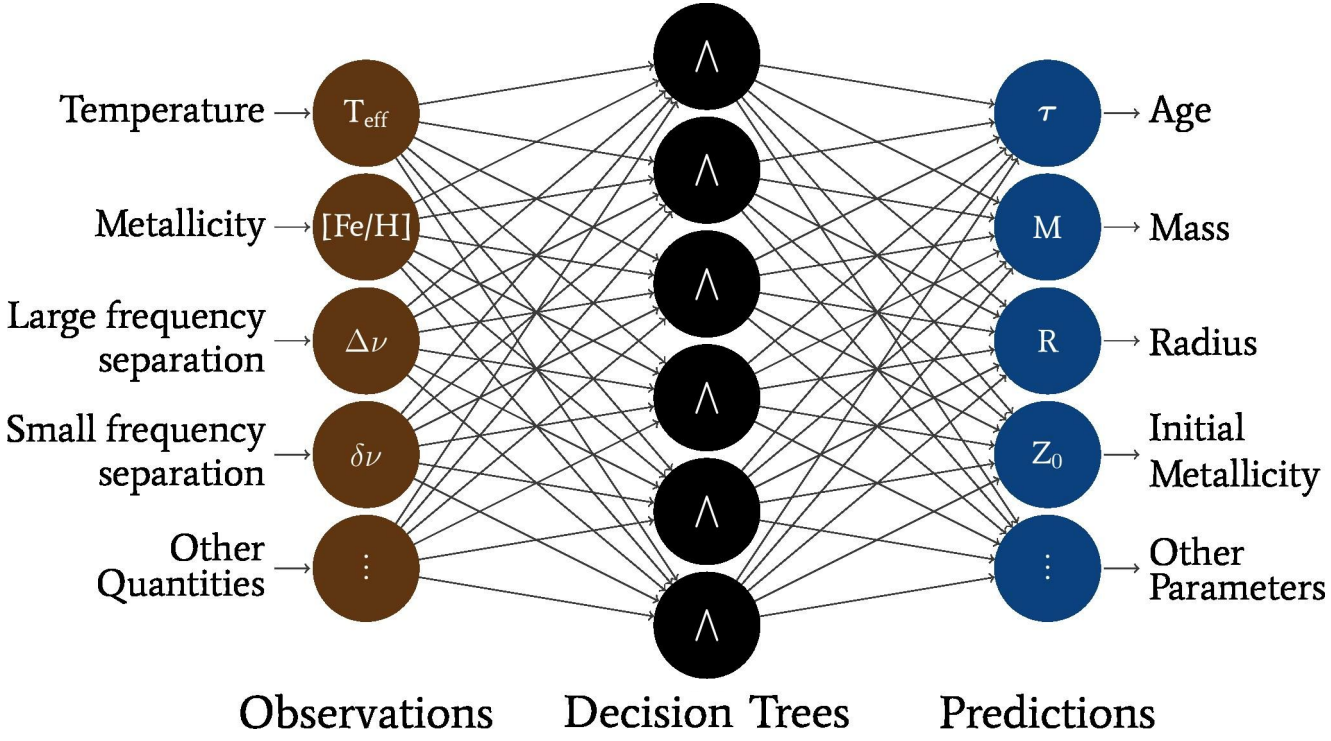
Fundamental Parameters in an Instant with Machine Learning: Application to *Kepler* LEGACY Targets
Seismology of the Sun and Distant Stars

Estimating Stellar Parameters



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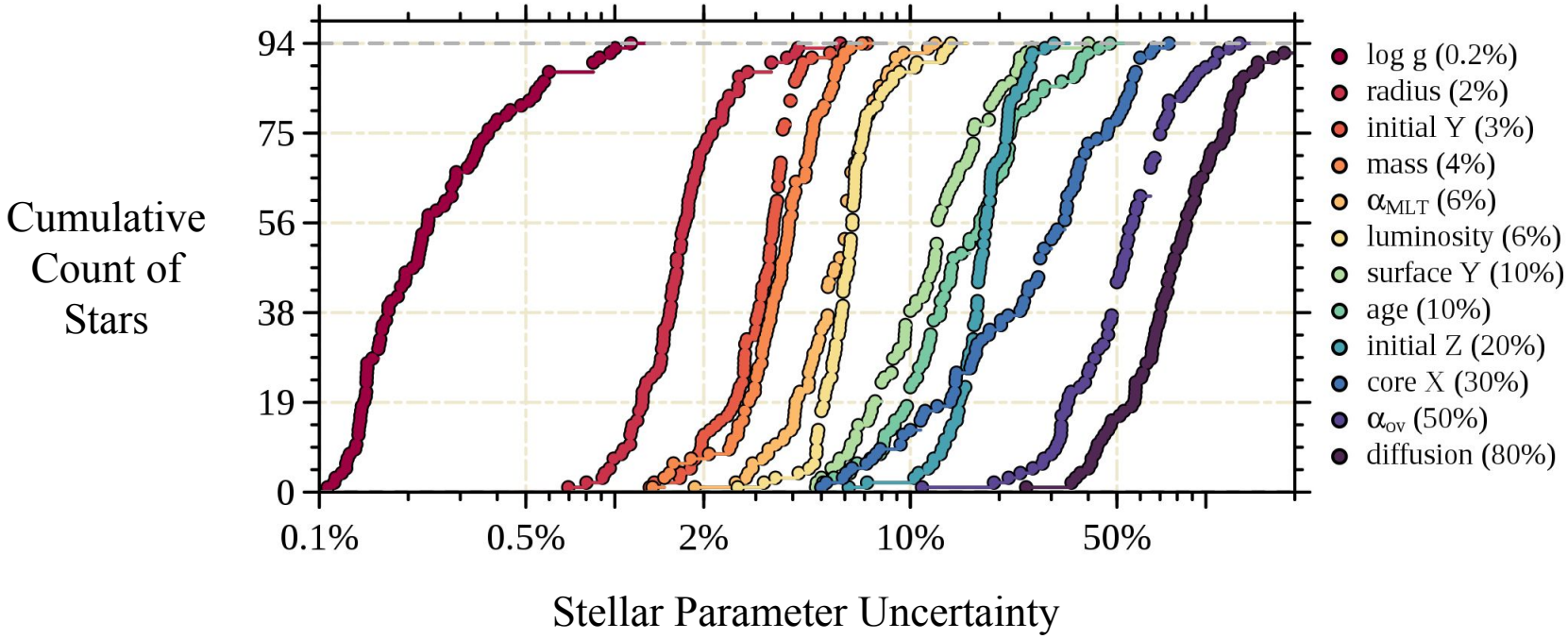
Precision of Stellar Parameters from Asteroseismology



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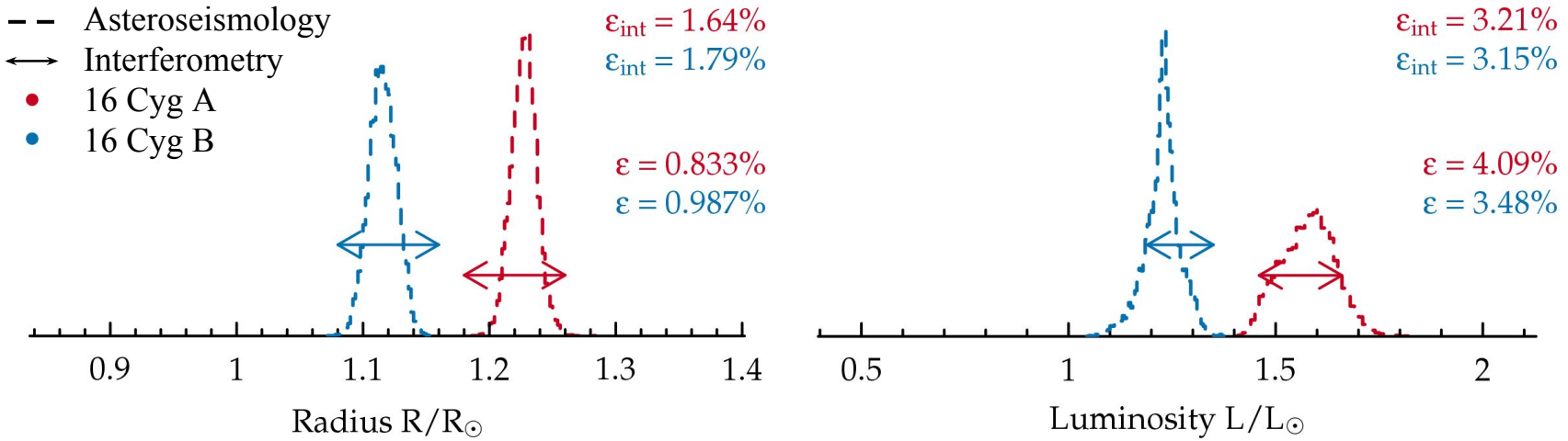
Accuracy of Stellar Parameters from Asteroseismology



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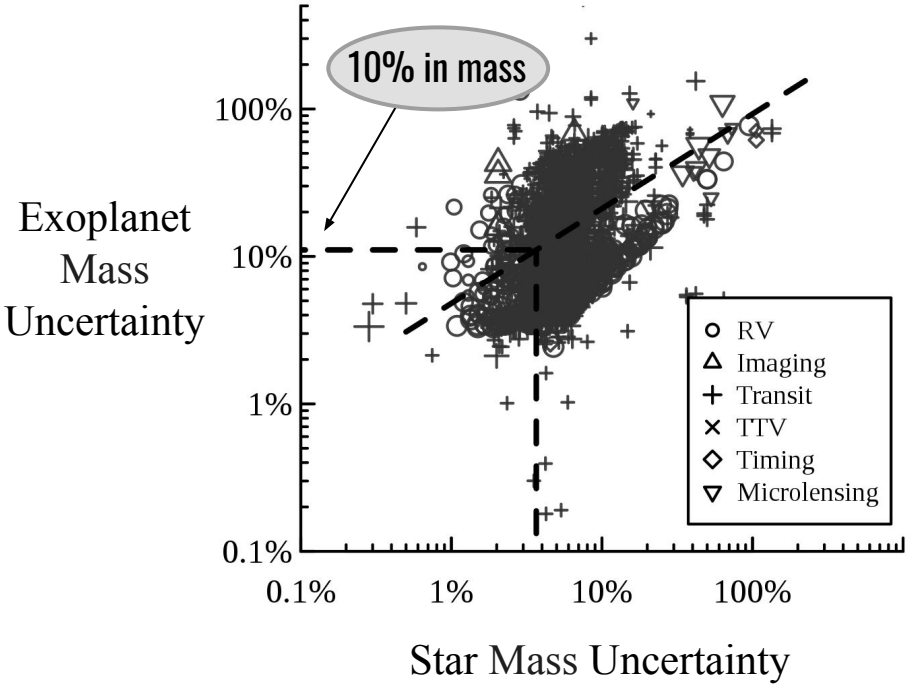
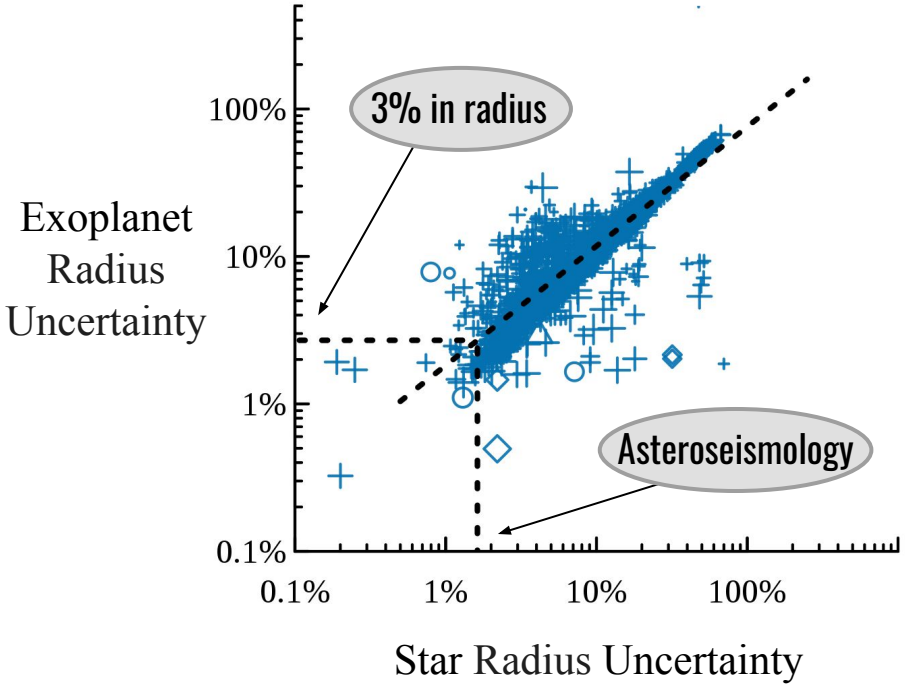
Planetary Parameters Depend on Stellar Parameters





Summary

- We have developed a technique for precise estimates of stellar parameters that costs only seconds per star (Bellinger & Angelou et al. 2016, 2017)

- Asteroseismology gives **stellar masses and radii to better than 5%**
  → exoplanetary masses and radii of 10% and 3%

- Asteroseismology is the **best technique for determining ages of isolated stars (~10%)**
  → exoplanetary ages can be assumed to be the same

- The TESS (2018) and PLATO (2025) missions will yield orders of magnitude more exoplanets and pulsating host stars (Angelou & Bellinger et al. 2017)

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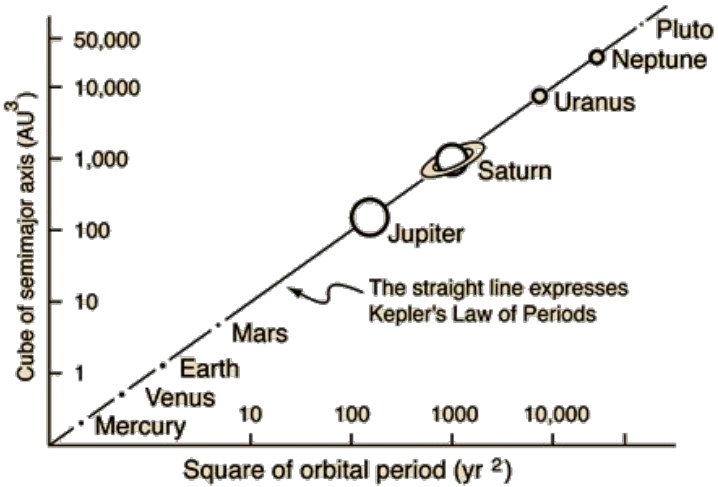
Appendix

Kepler's Third Law

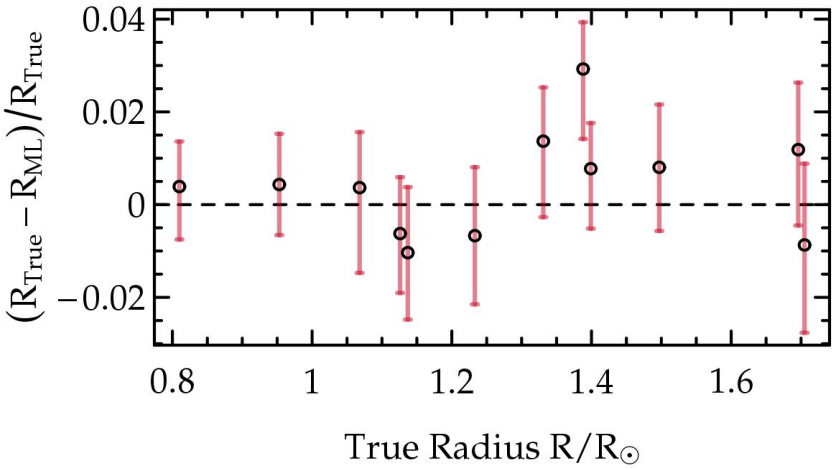
"...the proportion between the ***periodic times*** *of any two planets is precisely the sesquialternate proportion [i.e., the ratio of 3:2] of their* ***mean distances****..."*

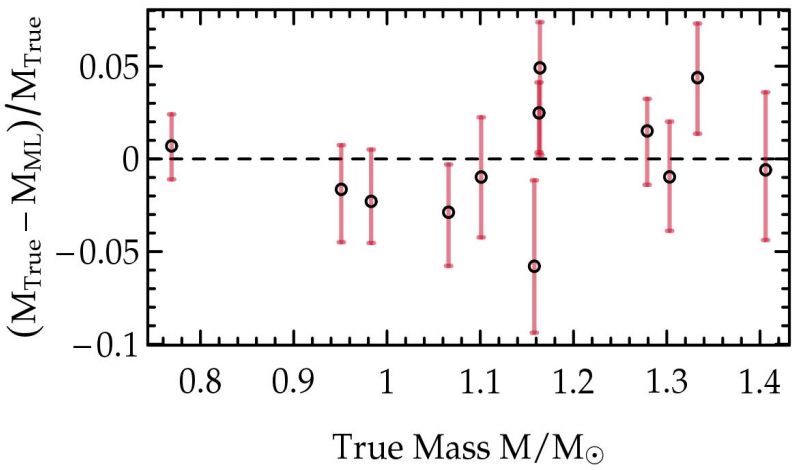


$$P^2 = \frac{4\pi^2 a^3}{G(M_* + M_{\rm p})}$$

$$\begin{pmatrix} P & = & \text{orbital period} \\ a & = & \text{semi-major axis} \\ M_* & = & \text{stellar mass} \\ M_{\rm p} & = & \text{planetary mass} \end{pmatrix}$$

Validation Tests on Stellar Models





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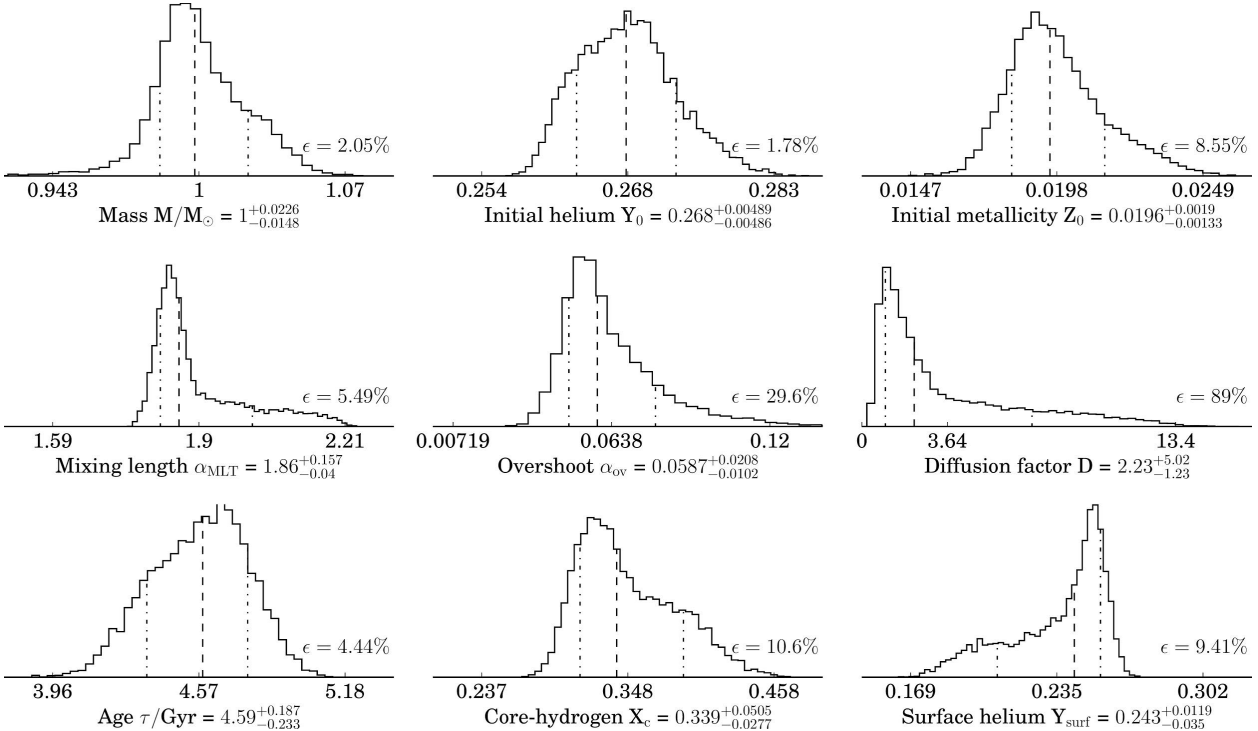
Validation Test on Degraded Solar Data



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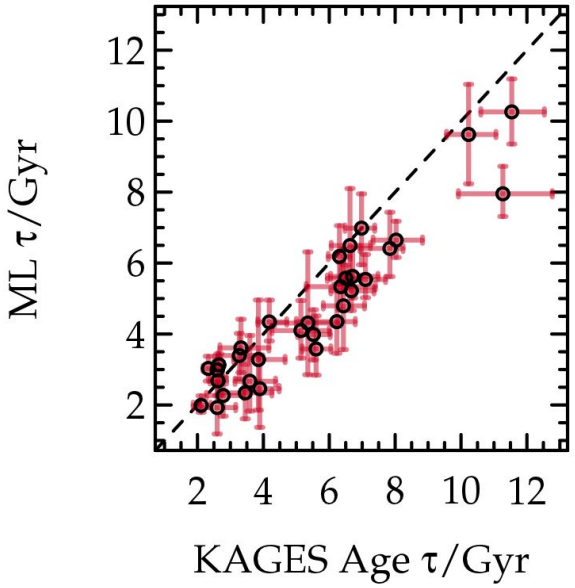
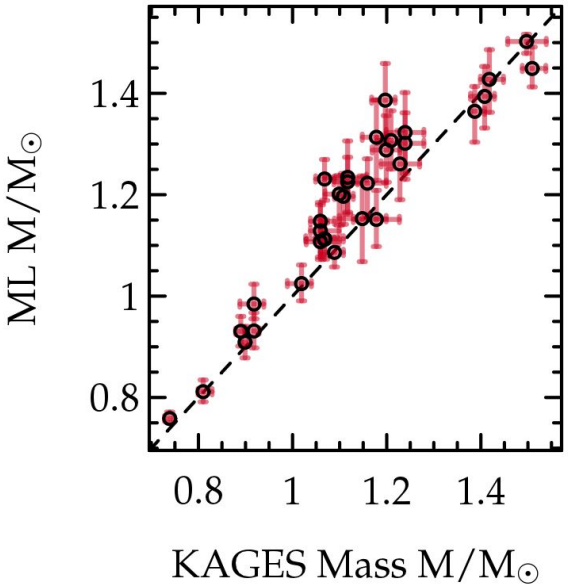
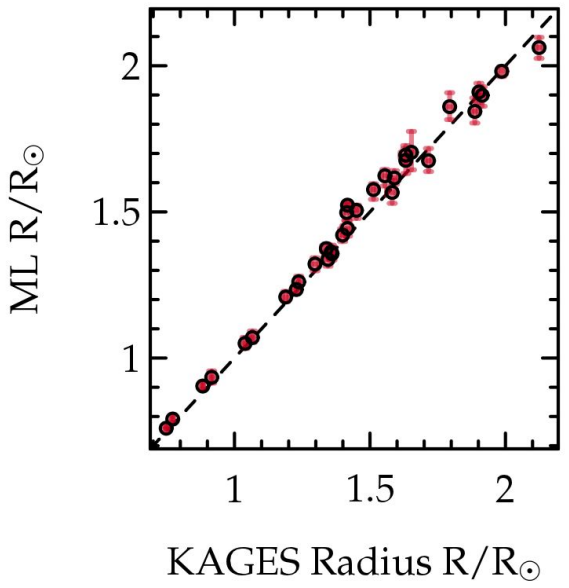
Comparison with other *Kepler Objects-of-Interest* estimates







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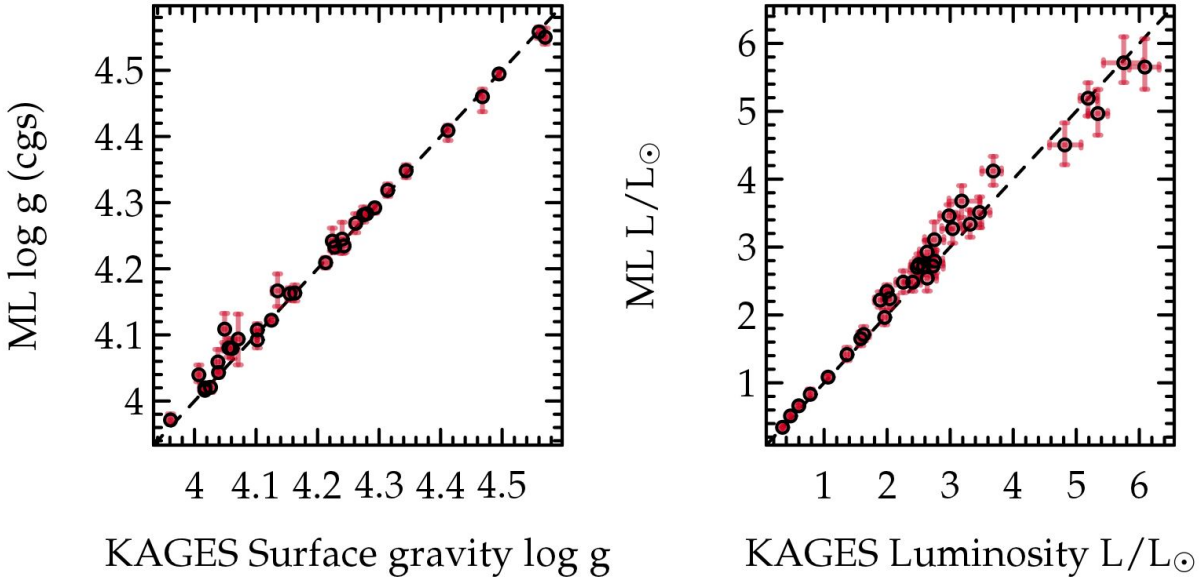

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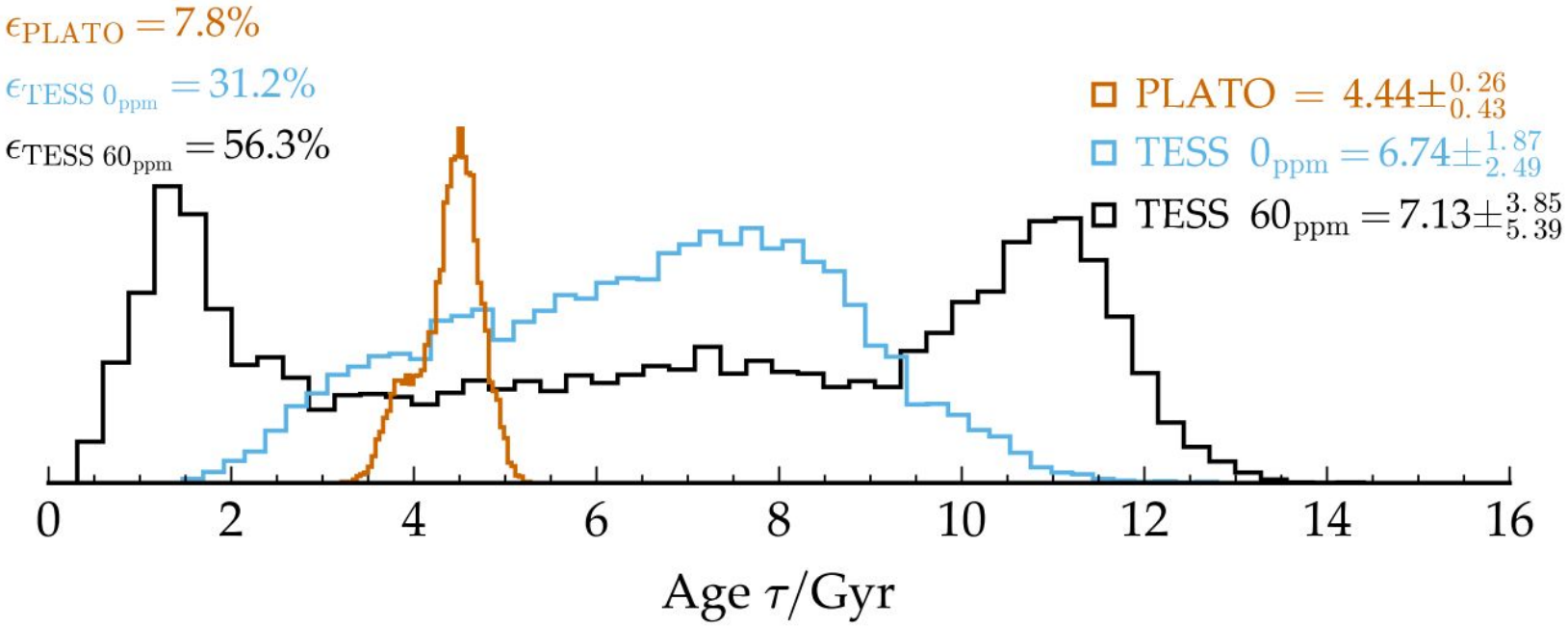
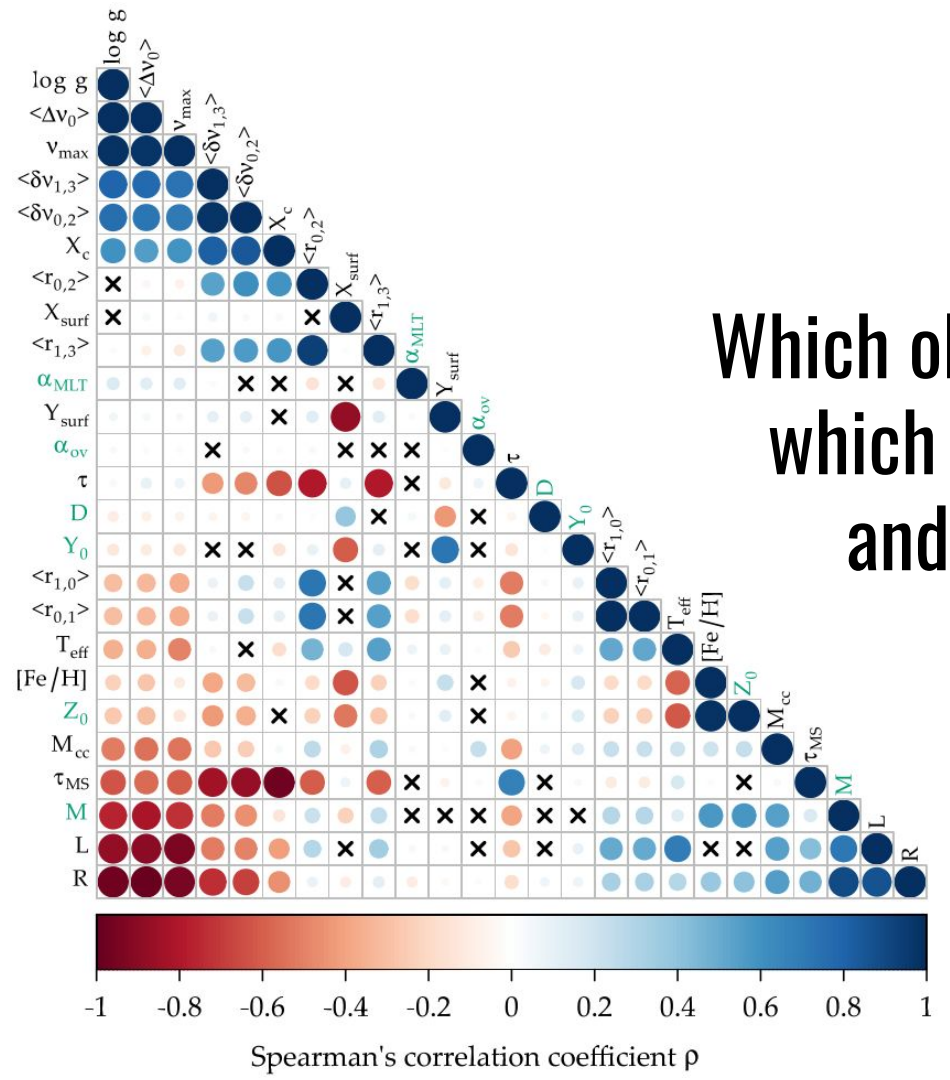
How will TESS and PLATO do on a star like the Sun?



Angelou, G. C., **Bellinger, E. P.**, Hekker, S., Basu, S. (2017)
On the Statistical Properties of the Lower Main Sequence
The Astrophysical Journal, 839 (2), 116



Which observations constrain which stellar parameters, and to what extent?

Angelou, G. C., **Bellinger, E. P.**, Hekker, S., Basu, S. (2017) On the Statistical Properties of the Lower Main Sequence *The Astrophysical Journal*, 839 (2), 116

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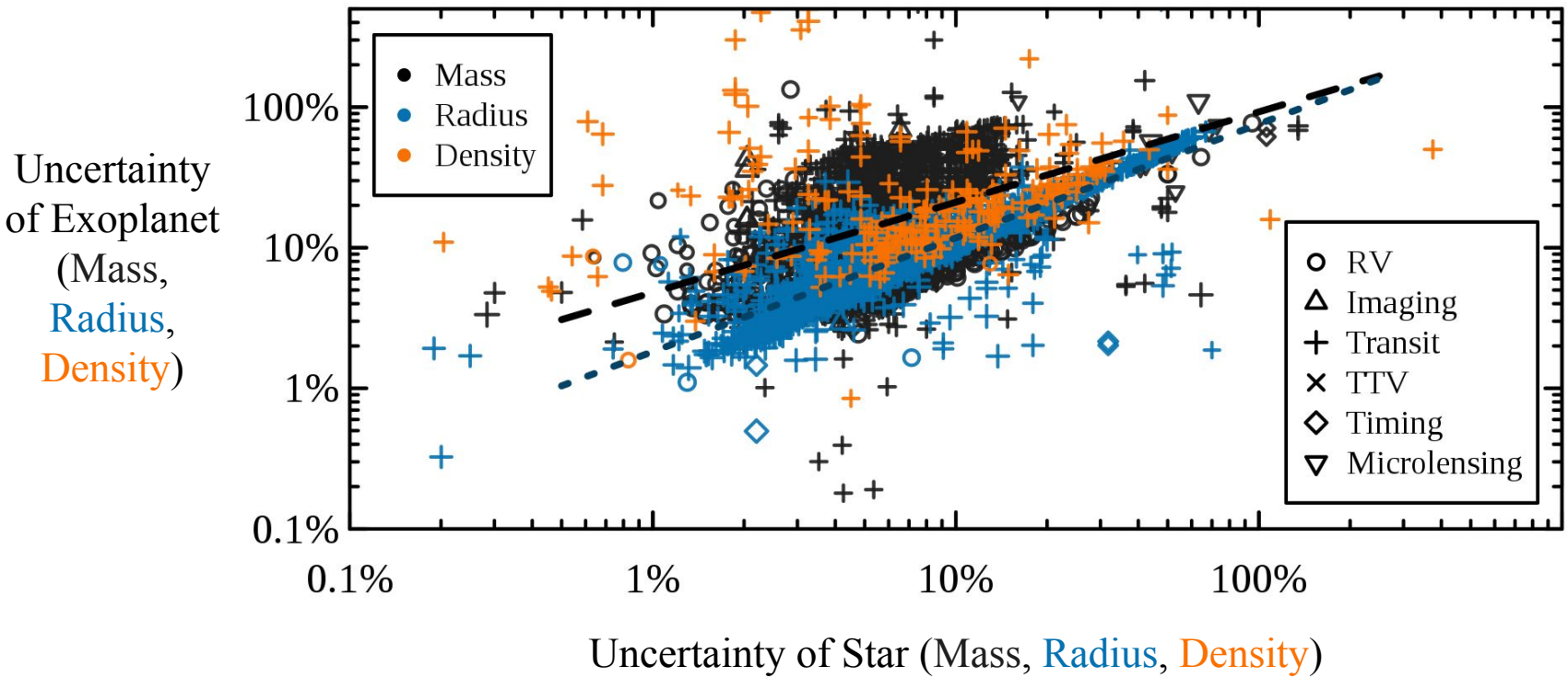

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