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Asteroseismology & Exoplanets
Summing up and future challenges

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Planet-Star Connections in the Era of TESS and Gaia

KITP, 20 May 2019

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What I'll cover

- On future challenges…

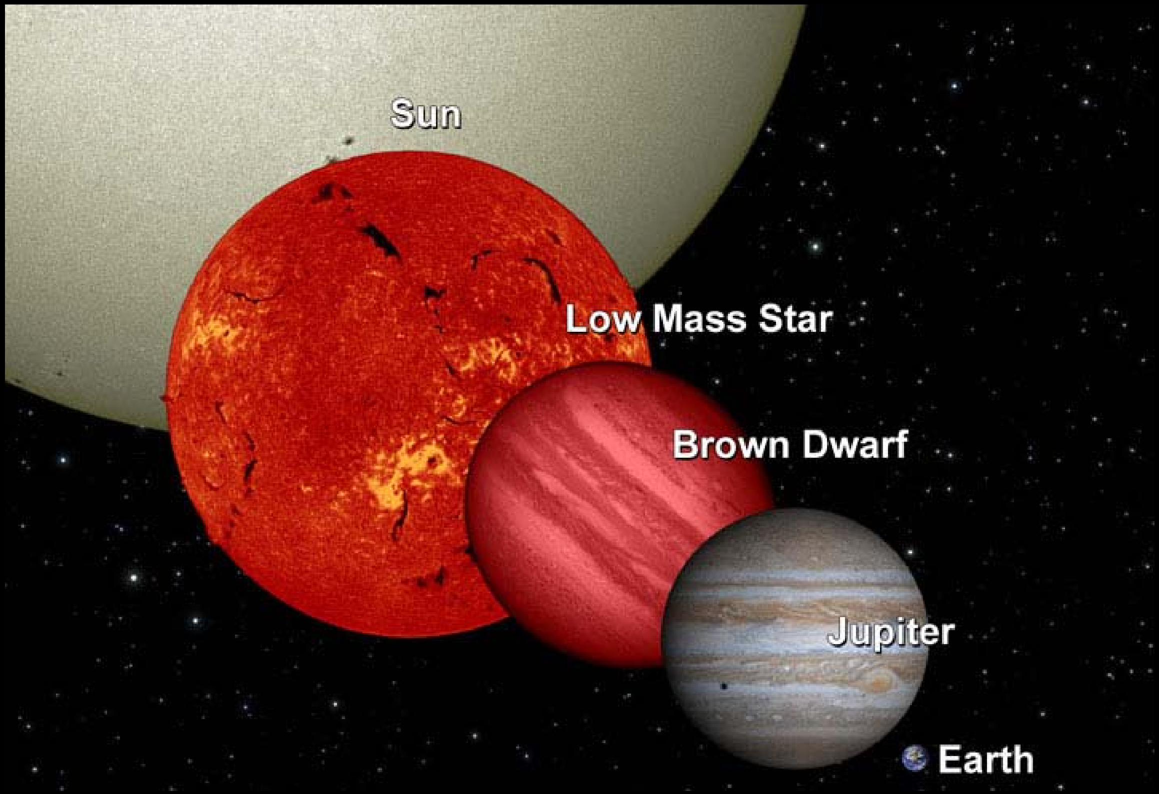
  Asteroseismology: low-mass stars & brown dwarfs

- Sum up…

  Reminders of what asteroseismology provides for studies of exoplanet systems

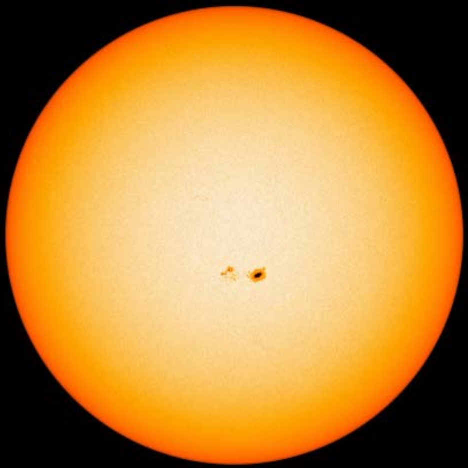
On future challenges

Asteroseismology: low-mass stars & brown dwarfs

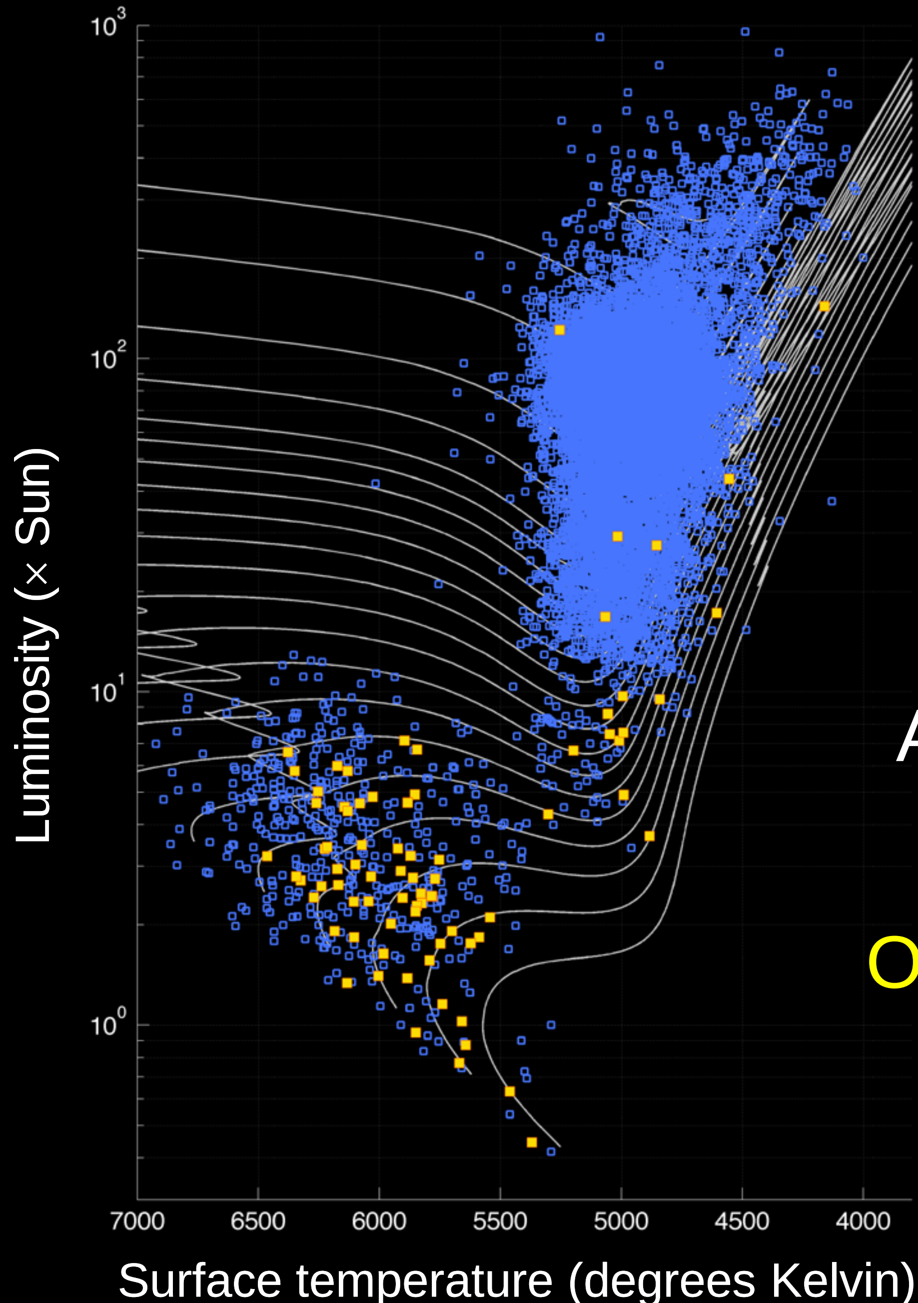


What’s a low mass on MS for an asteroseismologist?

For solar-like oscillators < $1M_\odot$



- But we have detections down to K dwarfs
- Aspiration: detect oscillations in early M dwarfs



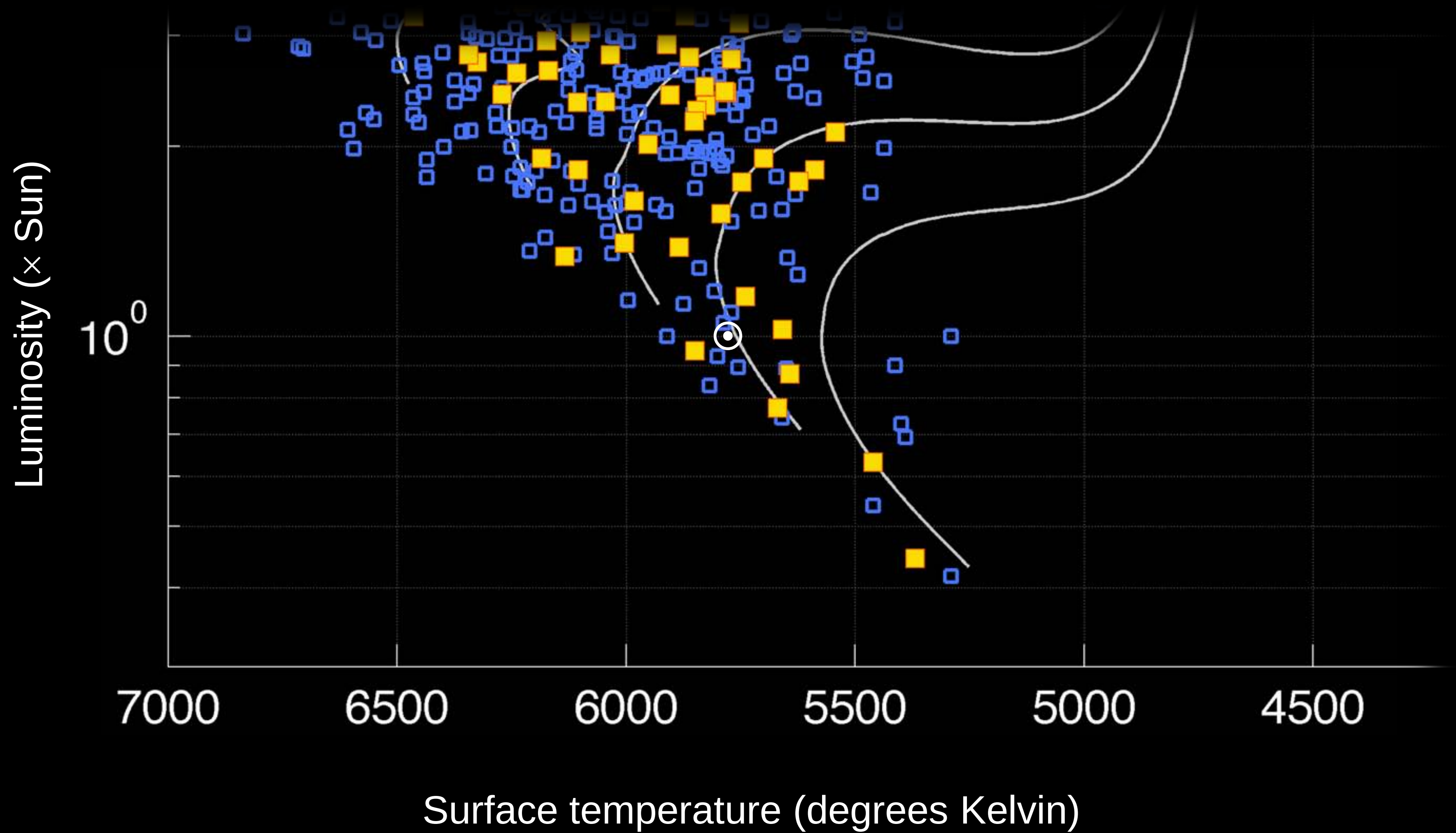
Asteroseismology of solar-like oscillators with *Kepler*

Approx. 700 solar-type stars

Approx. 20K+ red giants

Over 100 planet-hosting stars

At the cool end…



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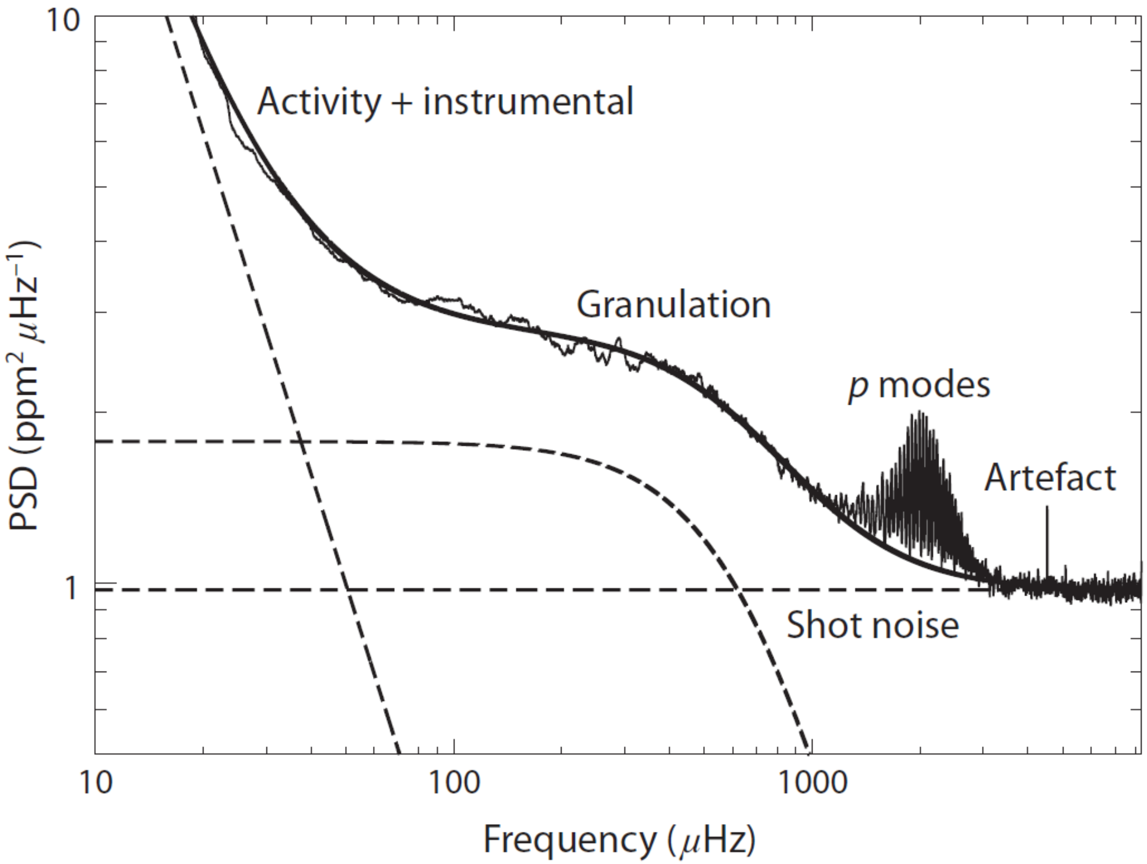
Frequency spectrum of high-cadence *Kepler* data

Planet host *Kepler*-410



Basu & Chaplin, Asteroseismic Data Analysis, Princeton University Press

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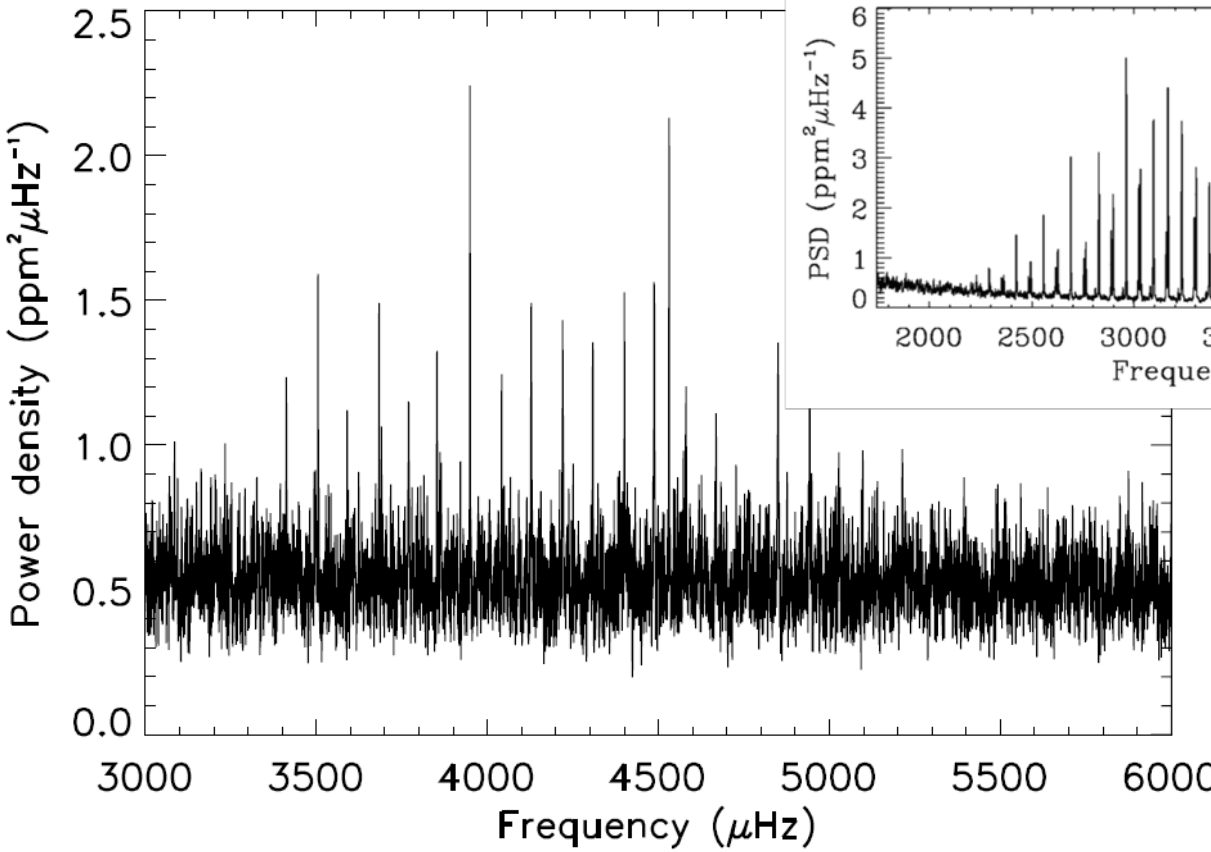
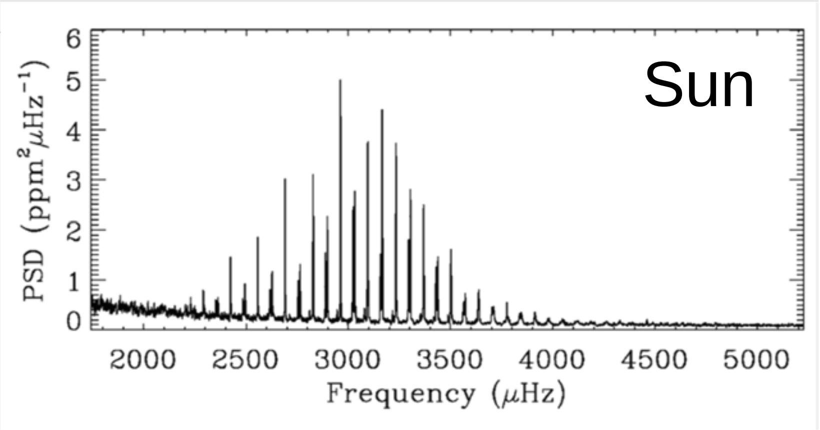
Oscillations in K dwarfs

Kepler-444 (K0V): highest density dwarf with detected solar-like oscillations





Campante et al., 2015, ApJ, 799, 170

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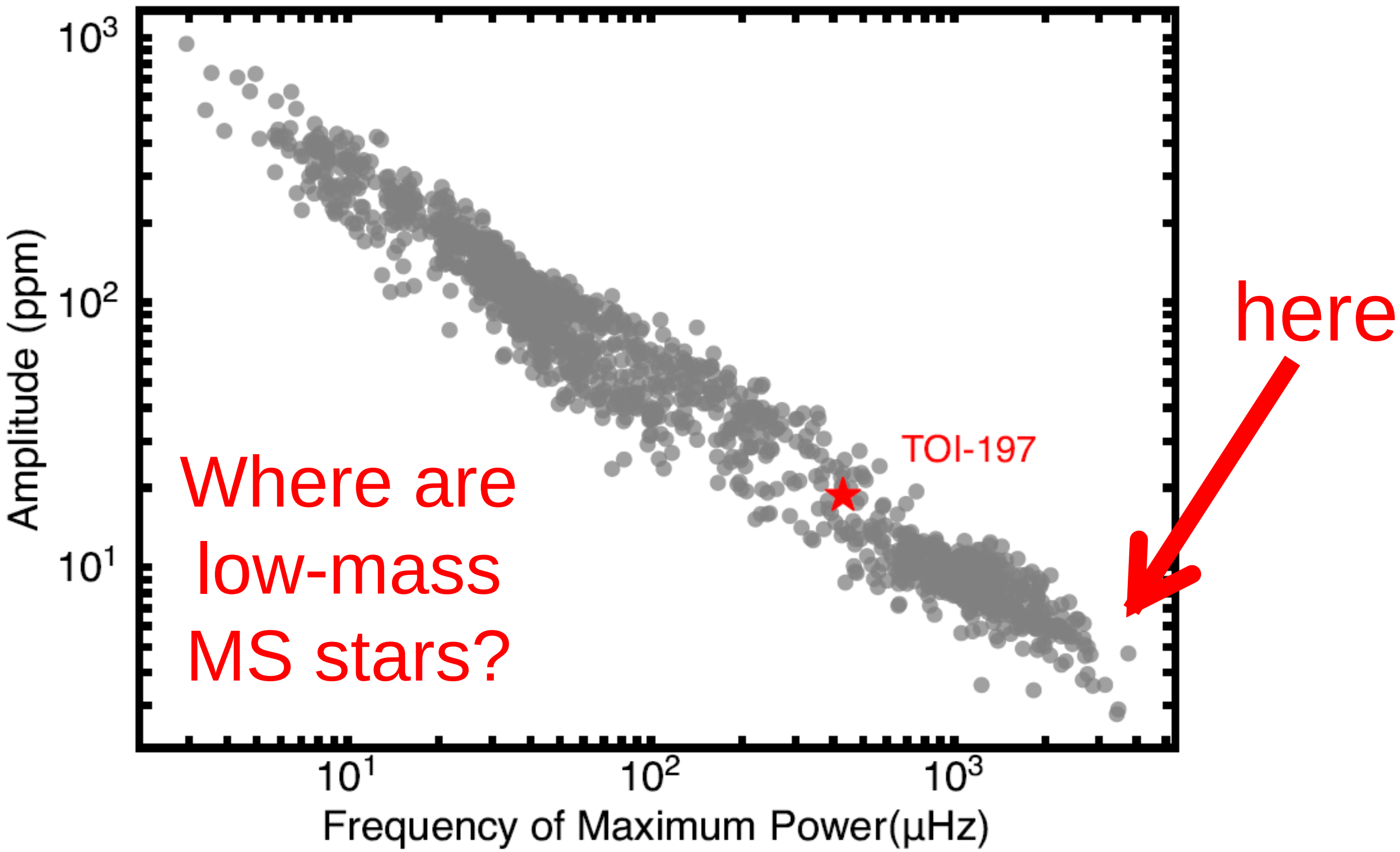
Low-mass MS stars have low oscillation amplitudes



Huber, Chaplin et al., 2019, ApJ, in press

Detecting solar-like oscillations in low-mass stars

Low-mass main-sequence stars:

- Show their strongest oscillations at high frequencies…
- Have very low photometric or Doppler velocity amplitudes

Detecting solar-like oscillations in low-mass stars

Detectability depends on:

- Intrinsic S/N in the oscillations [background has stellar (granulation) and non-stellar (shot/instrumental) noise]
- Sampling rate of the observations
- Length of the lightcurve

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Why didn't *Kepler* detect oscillations in M dwarfs?

- Did we have low enough noise to in principle make a detection?
  - *Likely yes*, for brightest/earliest-class M dwarfs
- So why didn't we?
  - Logistics: limited number of 60-sec slots, targets in the field(s), observed from the outset and for long enough…

ESA PLATO Mission

Bright stars; *Kepler* quality and dataset lengths; large sky coverage like TESS

esa

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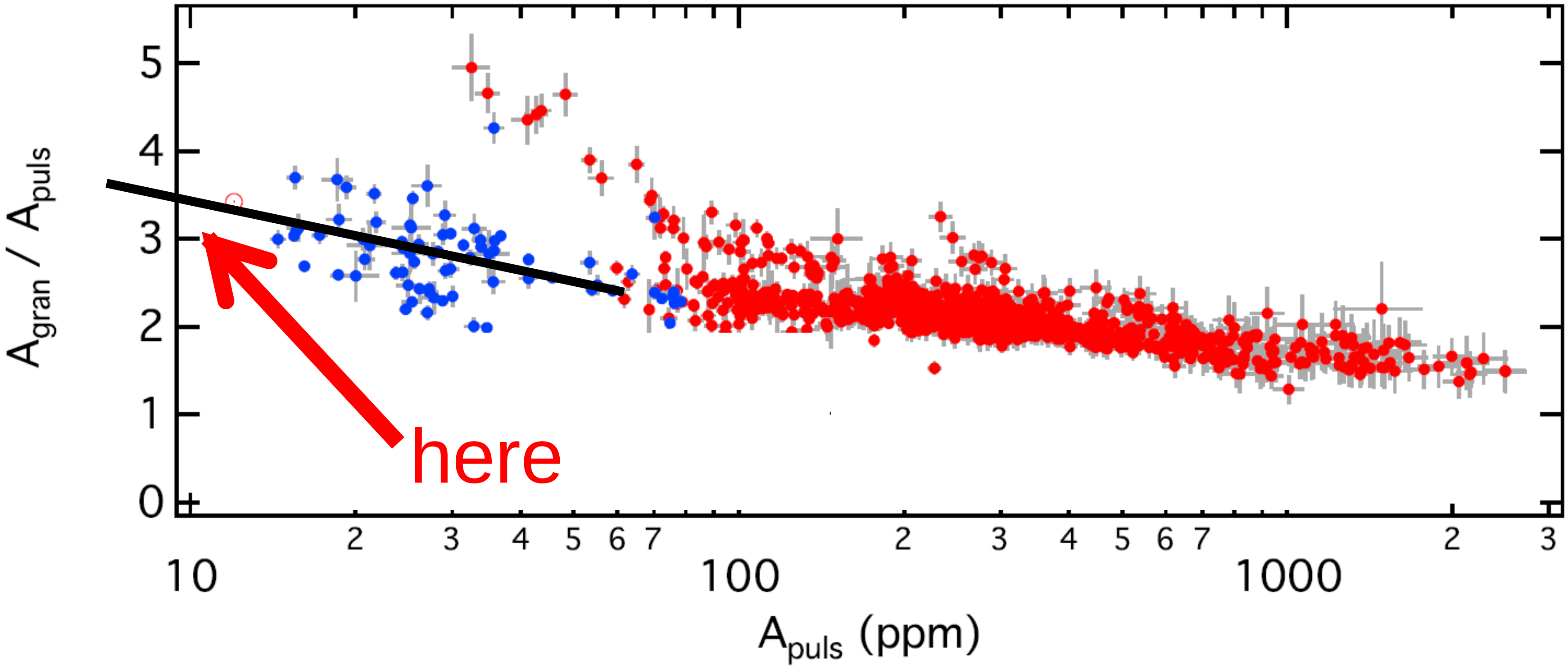
What about granulation?

Ratio RMS intensity fluctuations: granulation over pulsations



Kallinger et al., 2014, A&A, 570, A41

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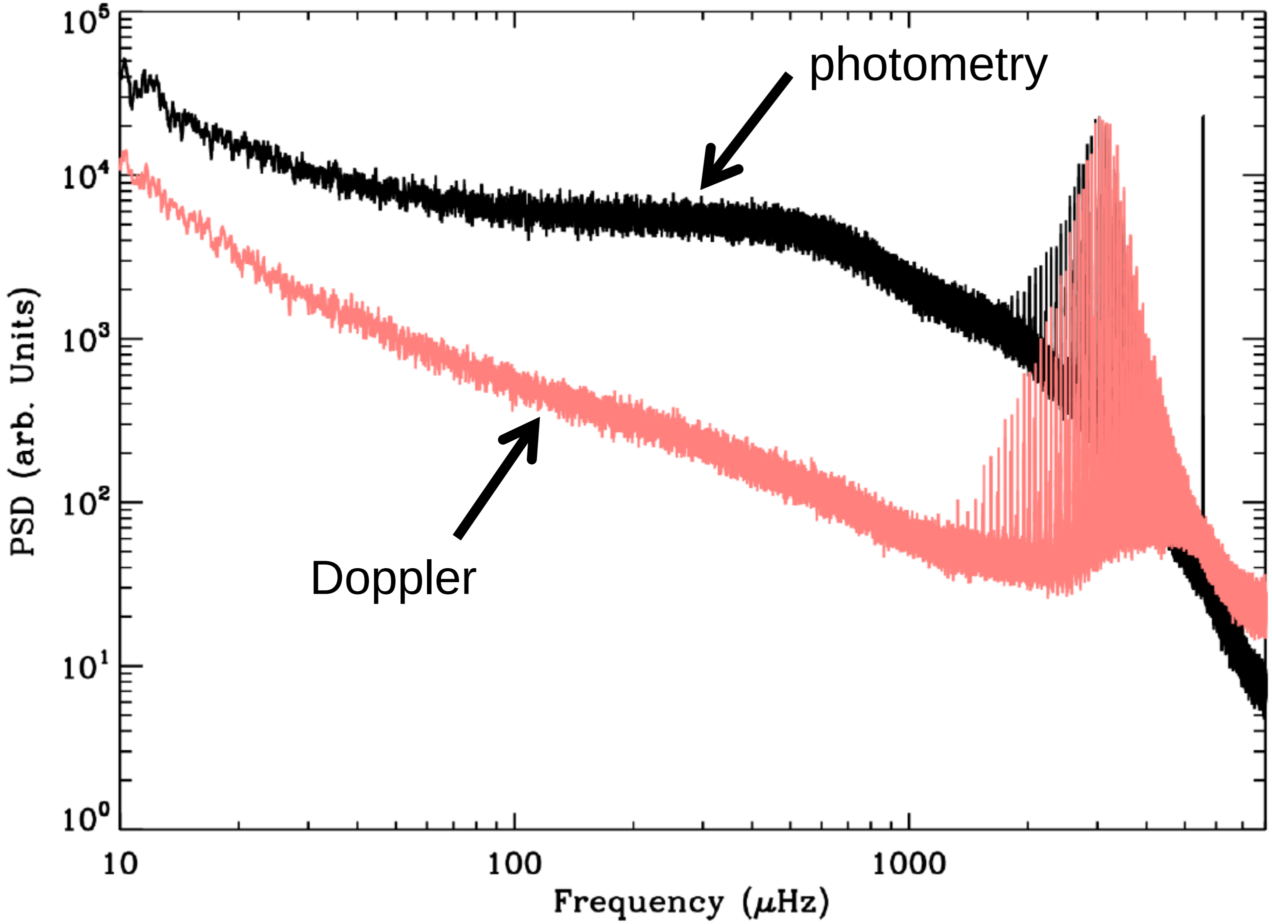
Sun-as-a-star in Doppler velocity and photometry



Garcia et al., 2013, J. Phys.: Conf. Ser. 440 012040

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Let's go brown….

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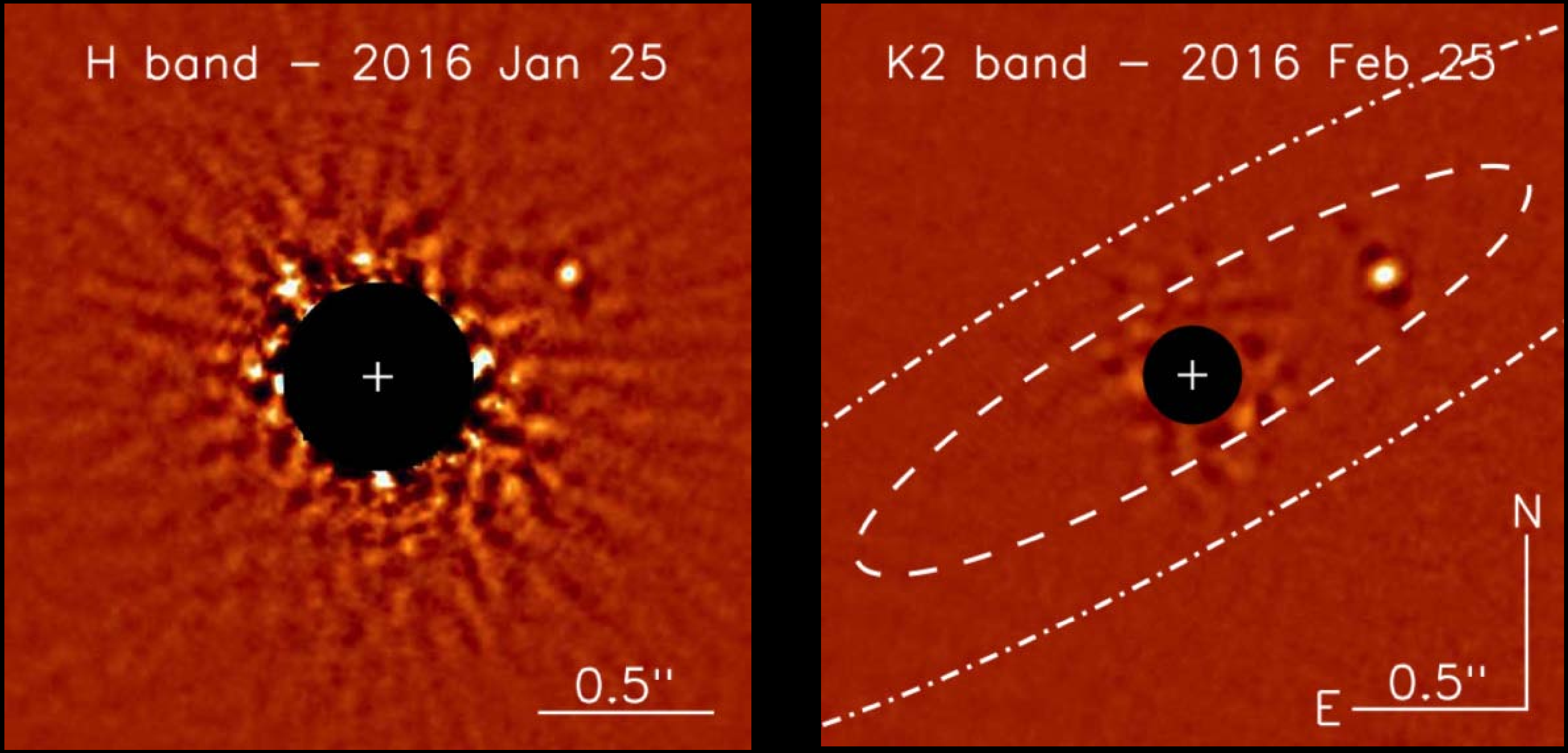
Brown dwarfs

- Hard to get constraints on ages
  - Colours/SED/CMD & parallax, kinematics, Li depletion, rotation, activity…
- Find widely separated systems with bright solar-type primary
  - Asteroseismology of primary for age
  - Test age estimation of secondary

HR 2562b

F5V primary (V=6.1), imaged brown dwarf secondary



Konopacky et al. 2016

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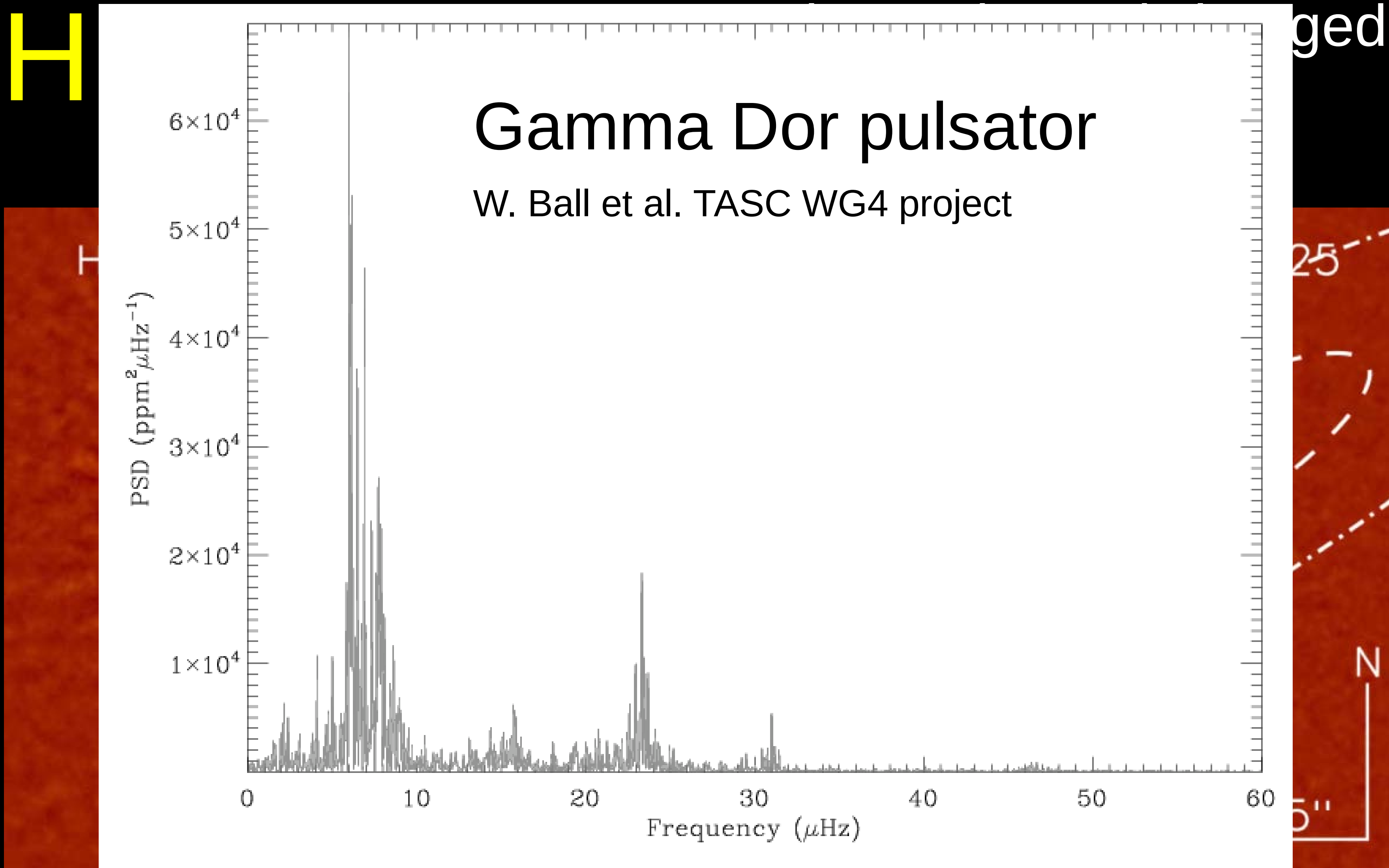

Konopacky et al. 2016

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Summing Up

Asteroseismic Input to studies of exoplanet systems

Direct

Indirect

Direct asteroseismic input

- Stellar properties or parameters for use in studies of specific systems or cohorts of systems:
  - Fundamental properties (i.e. stellar density, log *g*, radius, mass, age…)
  - “Dynamical” parameters (i.e. orientation of stellar spin-axis, rotation…)

Direct asteroseismic input

- We rely on being able to detect oscillations in the host stars:
  - Exoplanet detection limits bias sample size
  - Asteroseismic detection limits bias sample size

Indirect asteroseismic input

- Work that drives improvements in analysis and inference:
  - Use asteroseismology to improve stellar models, physics (overshooting, mixing, mass loss etc.)
  - Develop/improve our analysis techniques (e.g. use of model grids, combining seismic and non-seismic data etc.)

Indirect asteroseismic input

- Importance of benchmarking:
  - Use of other techniques to benchmark asteroseismology…
  - Use of asteroseismology to benchmark other techniques

Indirect asteroseismic input

- We need to be able to detect oscillations in *any* star
  - Asteroseismic detectability: same brightness limits as for planet hosts
  - But *much bigger* sample size for developing and testing analysis & inference

End