Sagan Summer Workshop

Poster Pops I
Monday, July 21

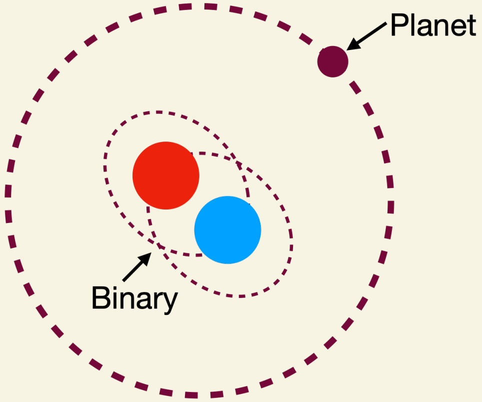
SAGAN SUMMER WORKSHOP

nexsci.caltech.edu/workshop/2025

NExScI

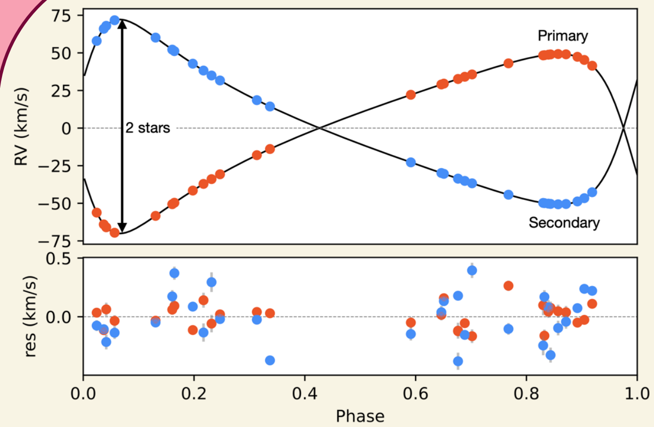
Detecting Circumbinary Planets Using Radial Velocity Methods

Aleyna Adamson
and
Amaury Triaud
axa2529@student.bham.ac.uk



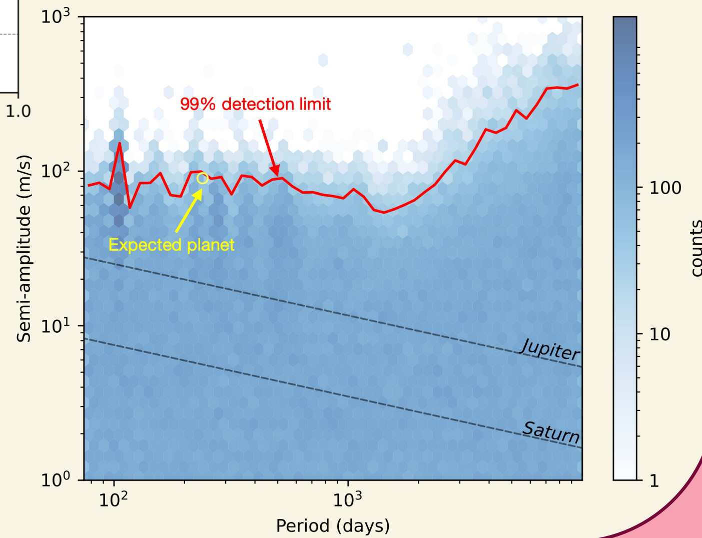
- **Circumbinary planets** are exoplanets that orbit both stars of a binary.
- Only 4 have been confirmed using radial velocities.
- **KIC 5095269** has a circumbinary planet found from eclipse timing variations.

Let's find it using RVs!



Phase folded radial velocities of KIC 5095269 using a new method to derive the RVs.

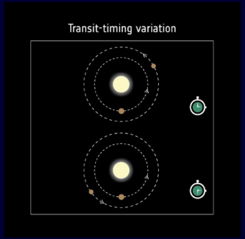
New method of calculating detection limits using nested sampling .



UNIVERSITY OF BIRMINGHAM
erc European Research Council

Mass-Radius-Period: the Exoplanet Essentials

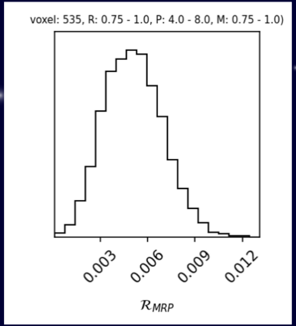
- We are trying to find the true distribution of exoplanet mass, radius, and period
- Masses are difficult to find, yet crucial for characterization!
- N-body integrations modeled jointly with lightcurves ("photodynamically") provide the best mass information—though only when TTVs are present



+

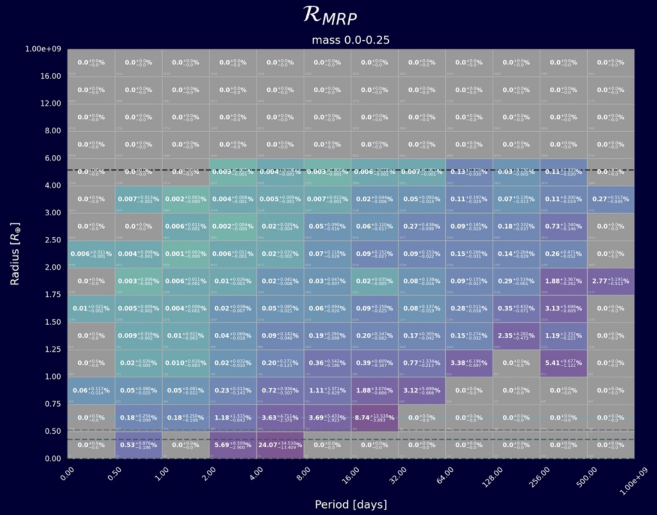
- A new dataset (the Kepler Multis Dynamical Catalog, or KMDC) photodynamically models >90% of all Kepler multiplanet systems.
- 1st-ever population-wide photodynamical analysis—mass posteriors for most all Kepler multis—over 100 planets have mass posteriors with <25% error

images:
https://www.esa.int/ESA_Multimedia/Images/2019/12/Detecting_exoplanets_with_transit-timing_variations
https://science.nasa.gov/exoplanets/whats-a-transit/

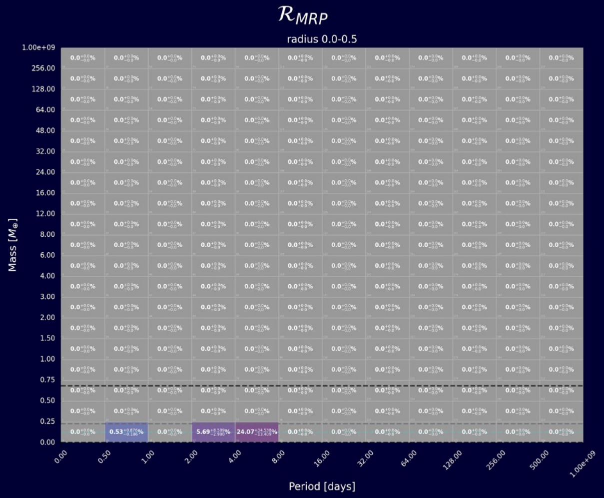


Our derived mass posteriors enable large-scale analysis of the mass-radius-period distribution

We use completeness to find the rate of planet per mass-radius-period bin in a non-parametric grid

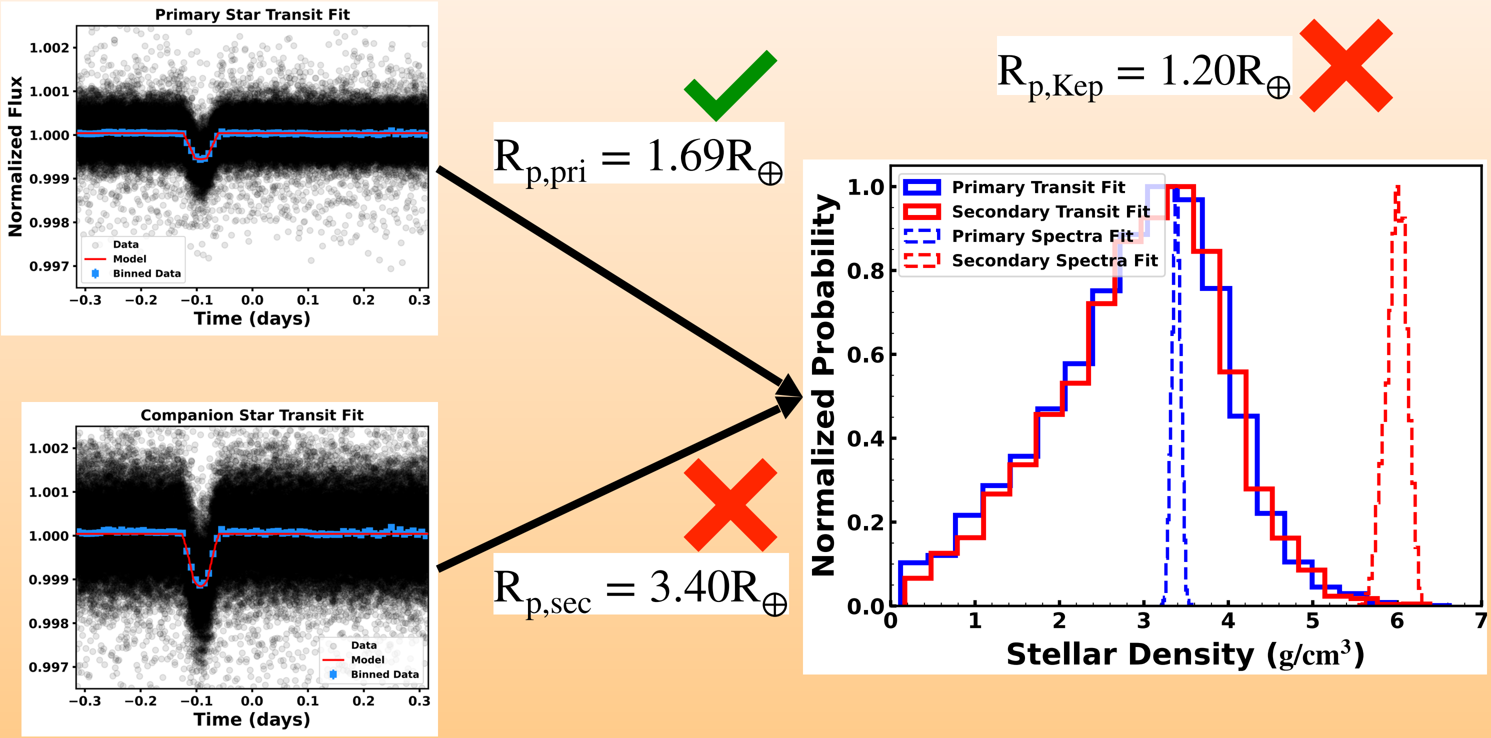


3D mass-radius-period demographic modeling



look for my poster, “Modeling the True Underlying Mass-Radius Period Distribution of Kepler Exoplanets”!

Determining the Host Stars of Planets in Binary Star Systems



Nathanael Burns-Watson

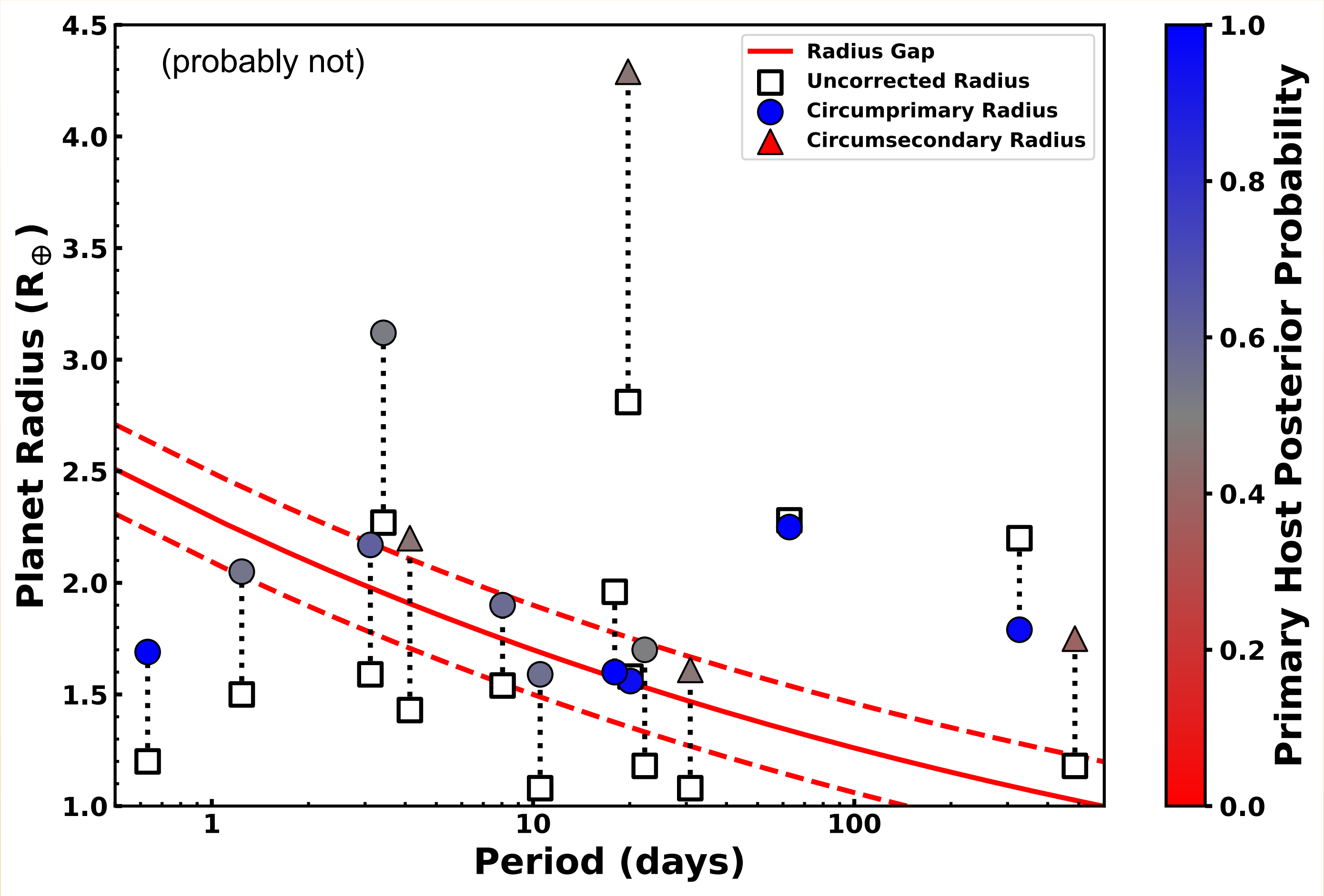
With: Dr. Kendall Sullivan and Prof. Adam L. Kraus

The University of Texas at Austin
Department of Astronomy
College of Natural Sciences

TACC
TEXAS ADVANCED COMPUTING CENTER

UC SANTA CRUZ

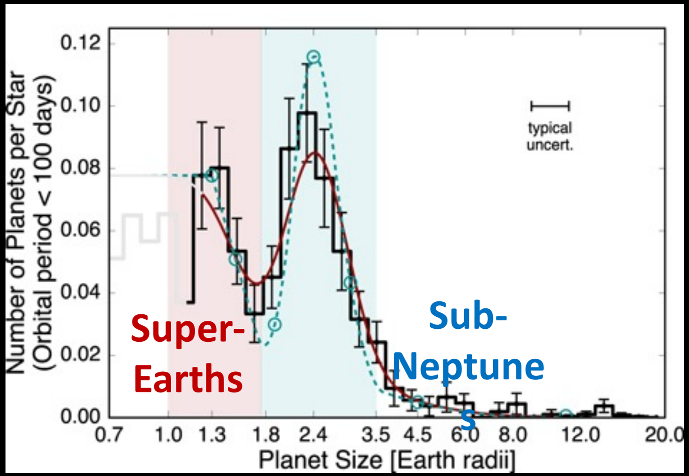
Is There A Radius Gap For Planets in Binaries?

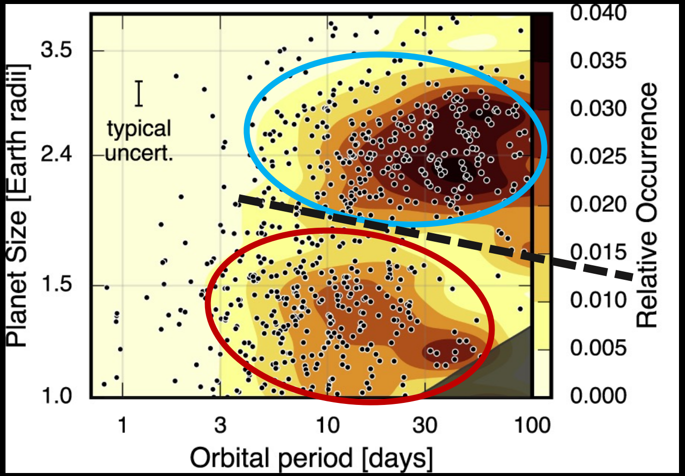


The Radius Cliff is a Waterfall: Explaining Sub-Neptunes as Steam Worlds

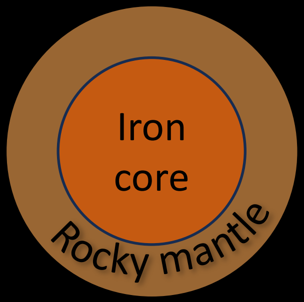
Aritra Chakrabarty
NPP Fellow, NASA Ames Research Center

Collaborators:
Gijs D. Mulders, *Pontificia Universidad Católica de Chile, Chile*
Artyom Aguichine, *University of California, Santa Cruz*
Natalie Batalha, *University of California, Santa Cruz*





Kepler planets
CKS sample
P < 100 days
(Fulton+ 2018)



Rocky super-Earths

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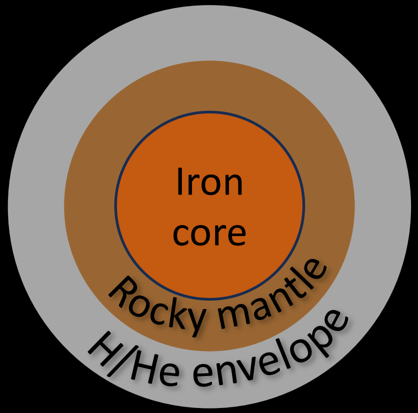
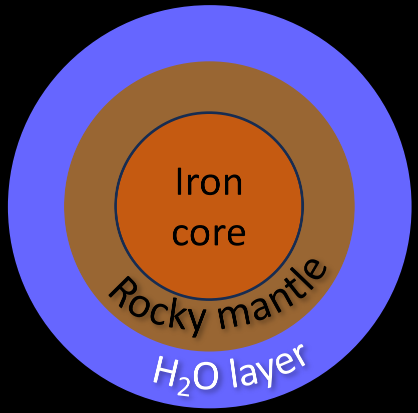


Gas dwarfs as sub-Neptunes
(Owen+ 2017, Lee+ 2015)

Or

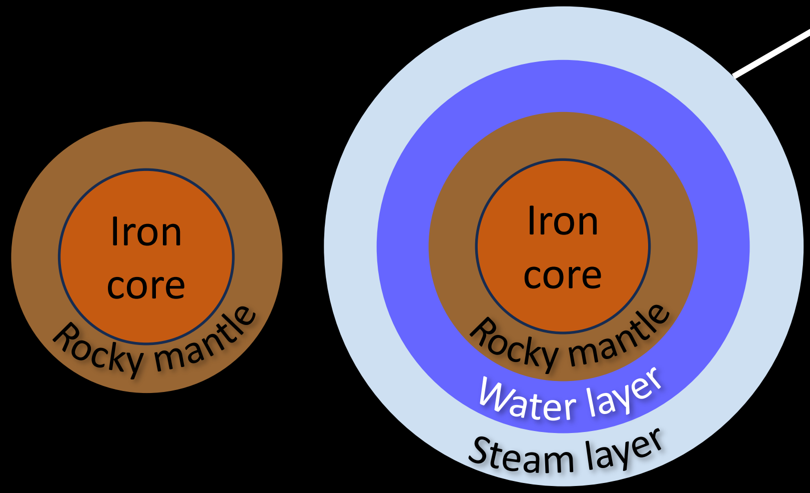


Water worlds as sub-Neptunes
(Mordasini+ 2009, Venturini+ 2020)

Sagan Summer Workshop 2025

Bayesian Hierarchical Model with Water/Steam Worlds

Model



Rocky planets as super-Earths (Zeng+ 2019)

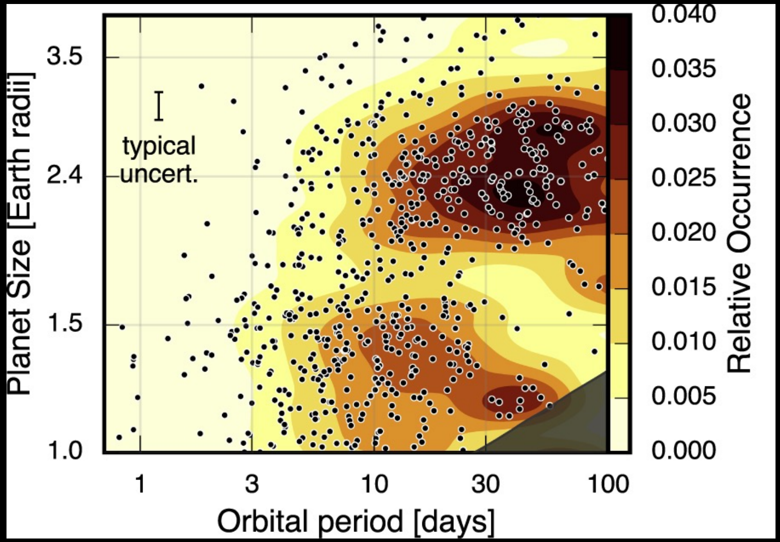
Steam worlds as sub-Neptunes (Aguichine+ 2021)

Irradiated and puffier, suitable candidates for sub-Neptunes

MCMC

max(log(P(Kepler-detection | Θ))

Θ = Model parameters

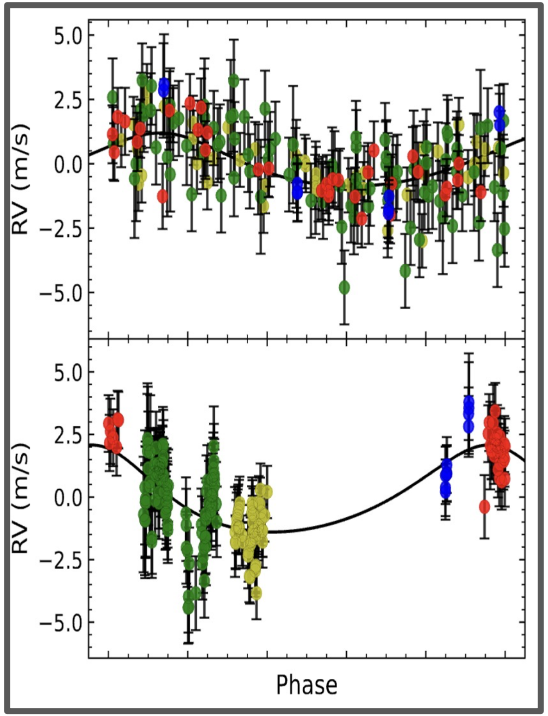


Kepler period-radius (Fulton+ 2018)

Check out our poster for to see the results and know more about our model!

HD 95735 c: New Dynamical Mass for a Nearby, Cold Neptune from the NEID Earth Twin Survey

Henry Dennen & Dr. Mark R. Giovinazzi
Amherst College Department of Physics and Astronomy
hdennen26@amherst.edu



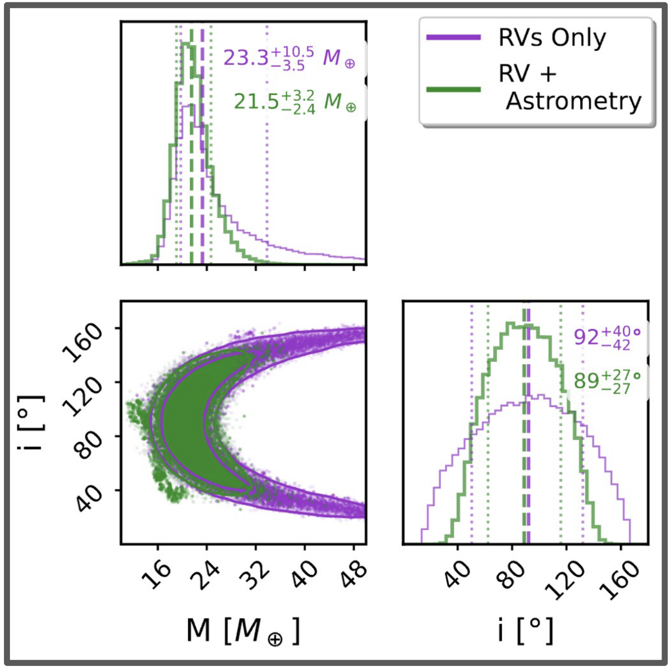
186 New High-Precision Radial Velocities!

+

A 2.2σ Acceleration from Hipparcos and Gaia Astrometry

=

A Unique Low Dynamical Mass!



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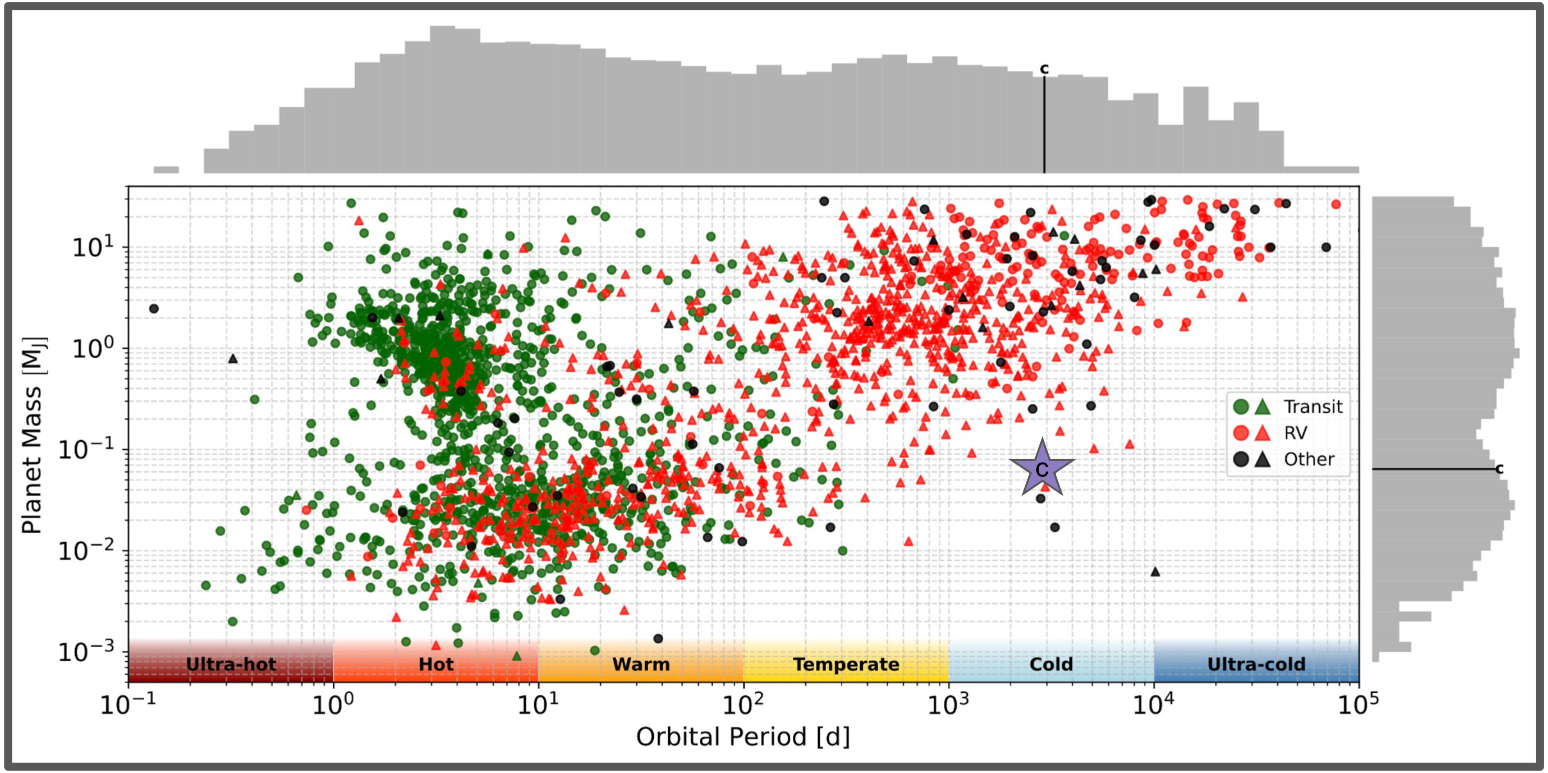
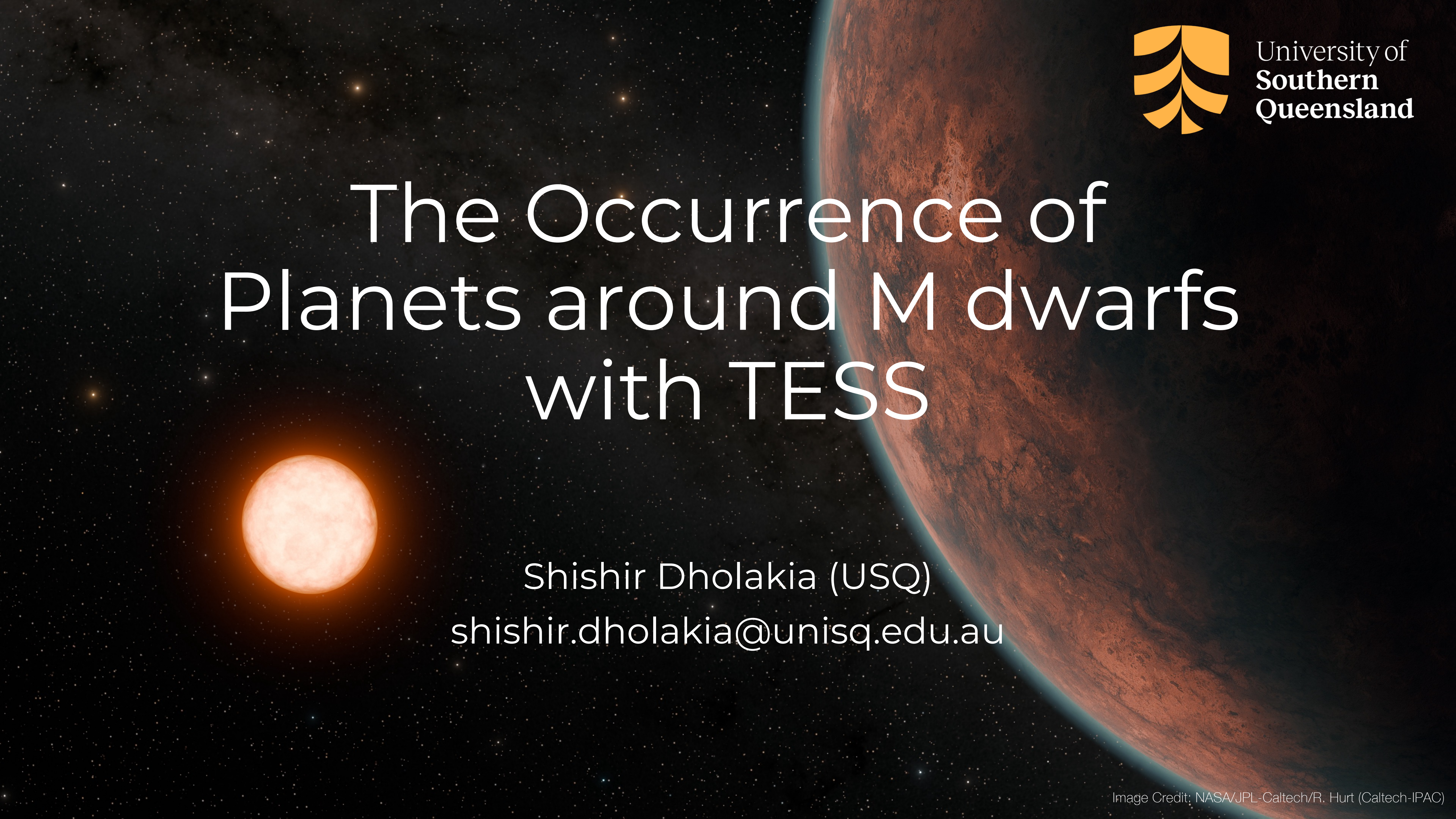


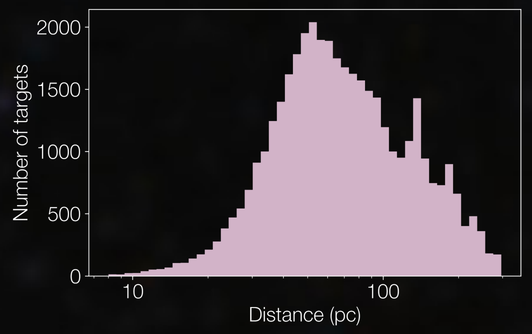


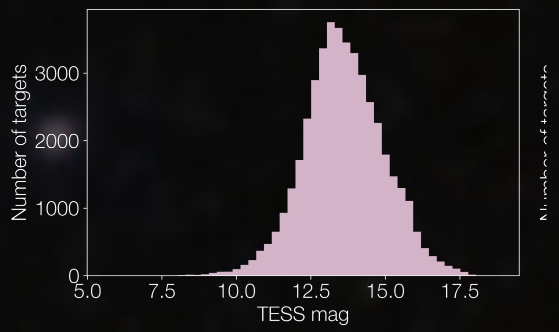
University of Southern Queensland

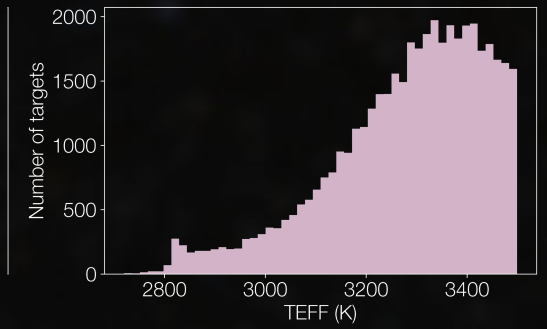
The Occurrence of Planets around M dwarfs with TESS

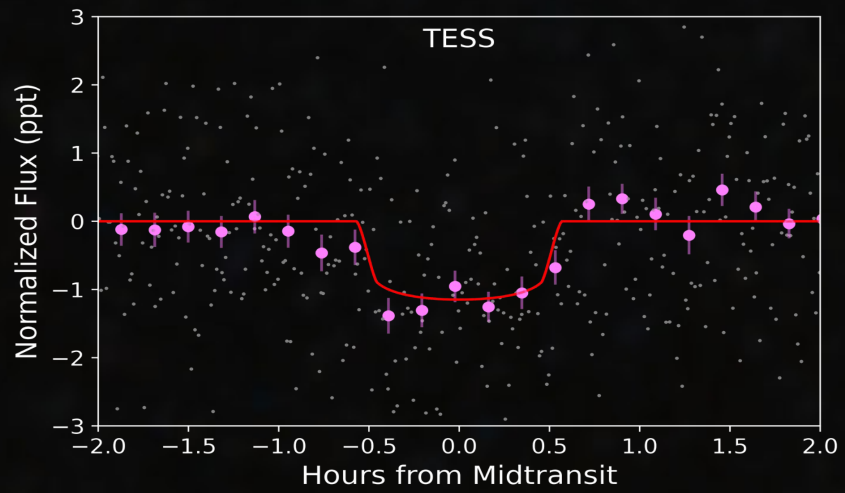
Shishir Dholakia (USQ)
shishir.dholakia@unisq.edu.au

Image Credit: NASA/JPL-Caltech/R. Hurt (Caltech-IPAC)









Stay tuned for the upcoming paper

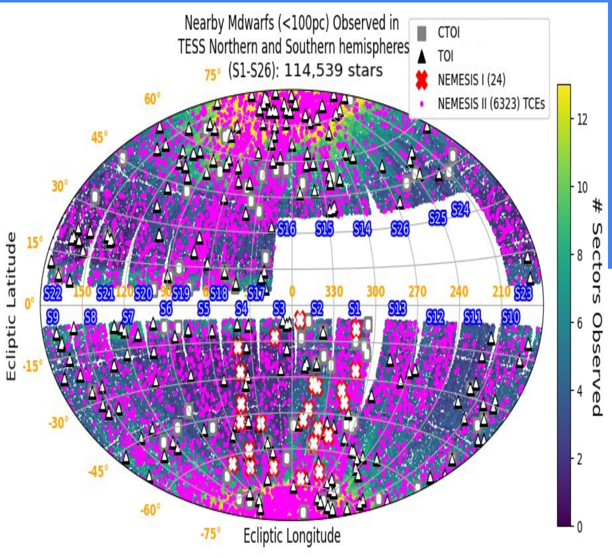
shishir.dholakia@unisq.edu.au

NEMESIS II: Exoplanet TraNsit SurvEy of Nearby M-dwarfs in TESS FFIS

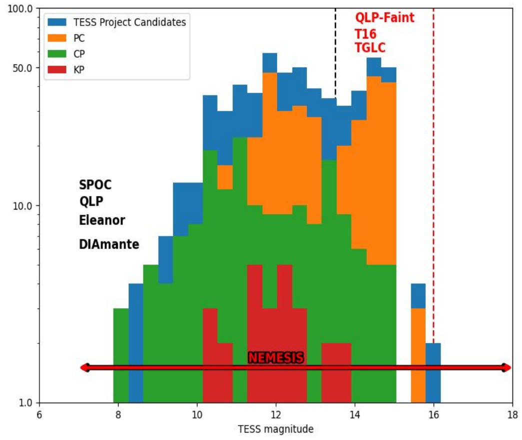
Dr. Dax Feliz et al.

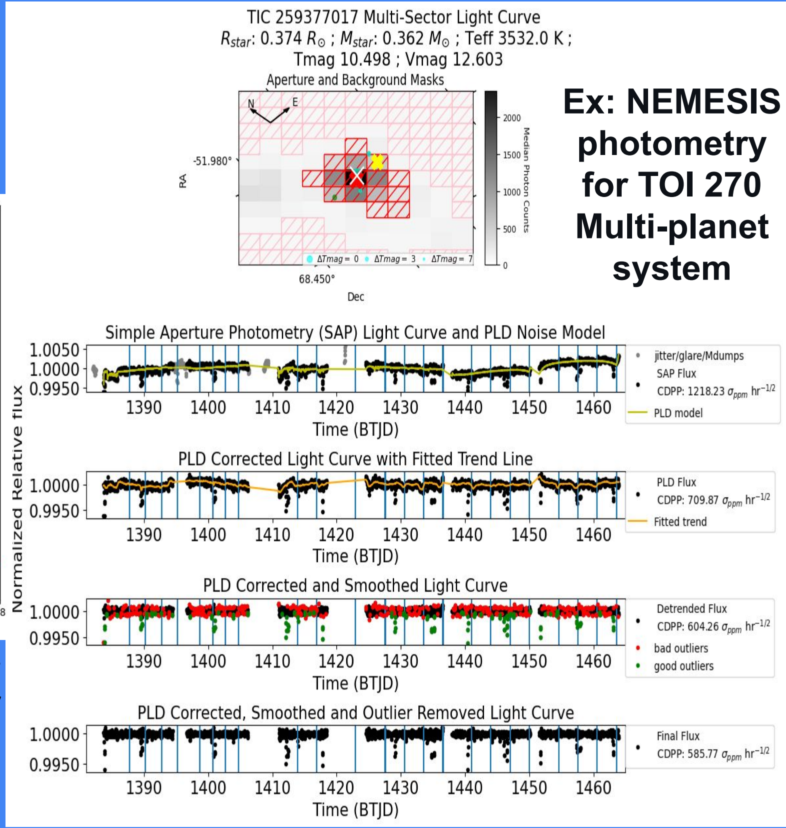
FLATIRON INSTITUTE

AMERICAN MUSEUM OF NATURAL HISTORY



TESS M-dwarf hosts and HLSP TESS magnitude regimes



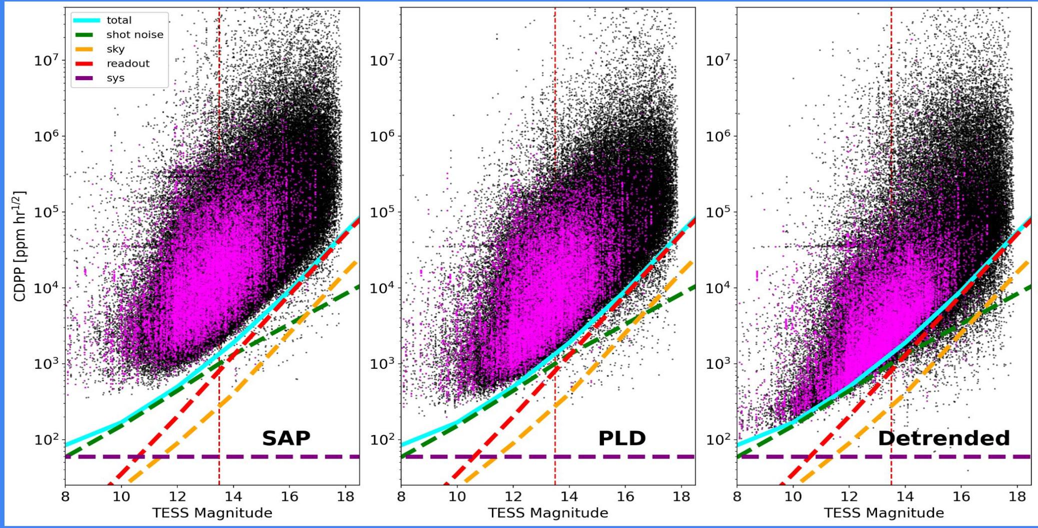


Ex: NEMESIS photometry for TOI 270 Multi-planet system

~220,000 light curves across Sectors 1 - 26

- **Nearby M-dwarfs have ~470 TOIs (group vetted) & 250 CTOIs (user vetted) with PC dispositions (as of 6/1/25)**

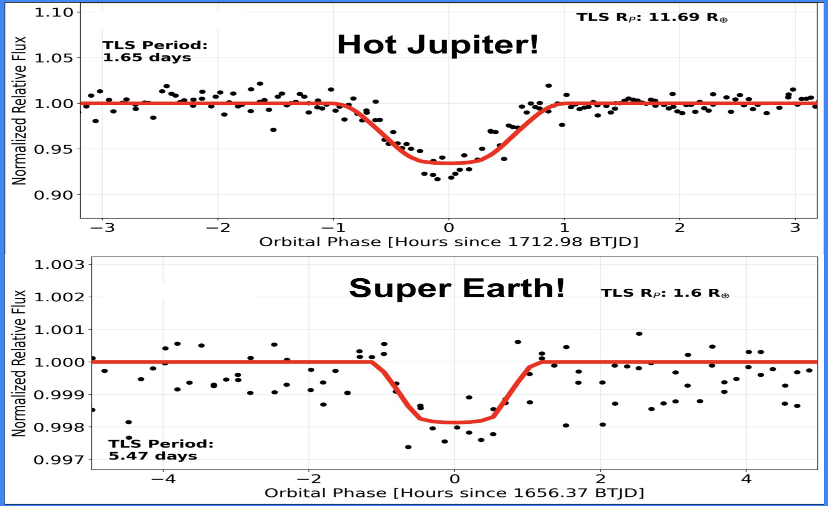
Photometric Precision of NEMESIS

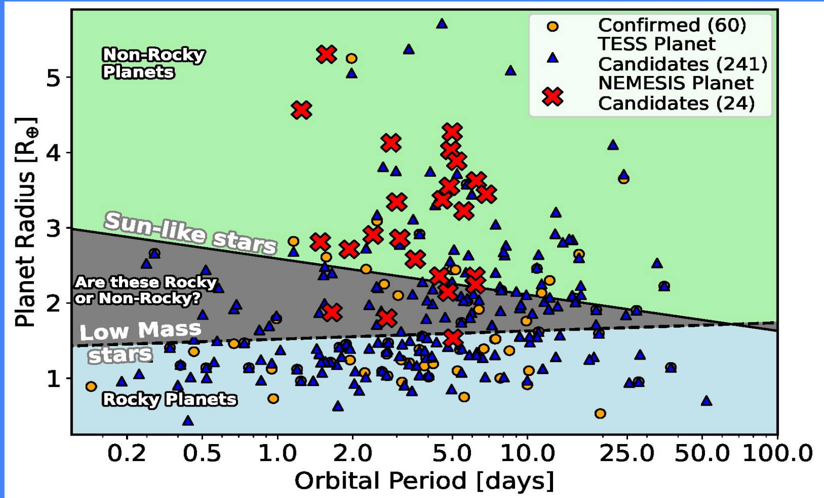


- NEMESIS II: > 6,200 auto-vetted TCEs (S/N > 10) from single-sector data; multi-sector, long-period search in prep (Feliz et al.).

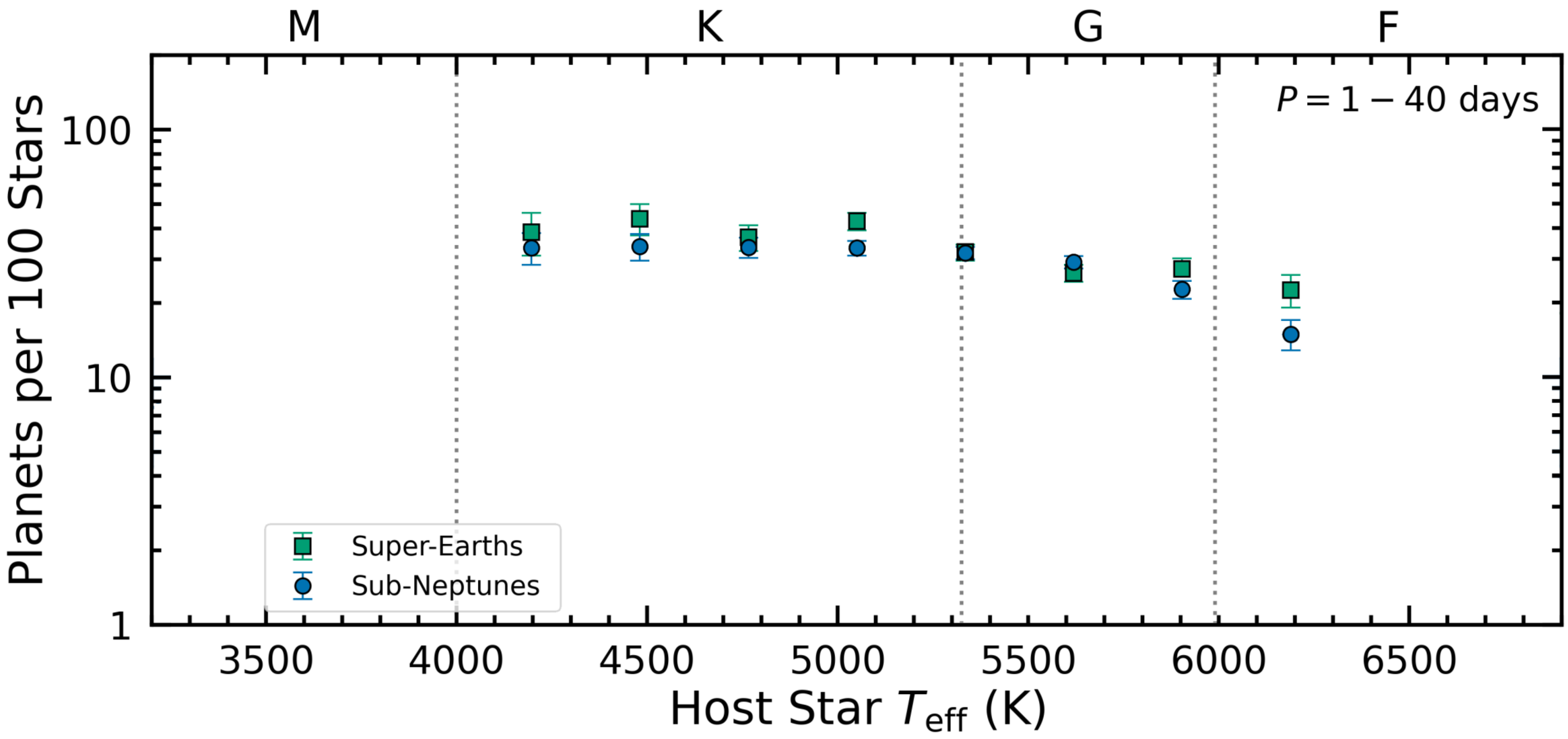
- The detections of new validated planet candidates through this ongoing project will significantly enhance TESS's ability to improve the statistical power of demographic studies in low mass star systems.

Example TCEs



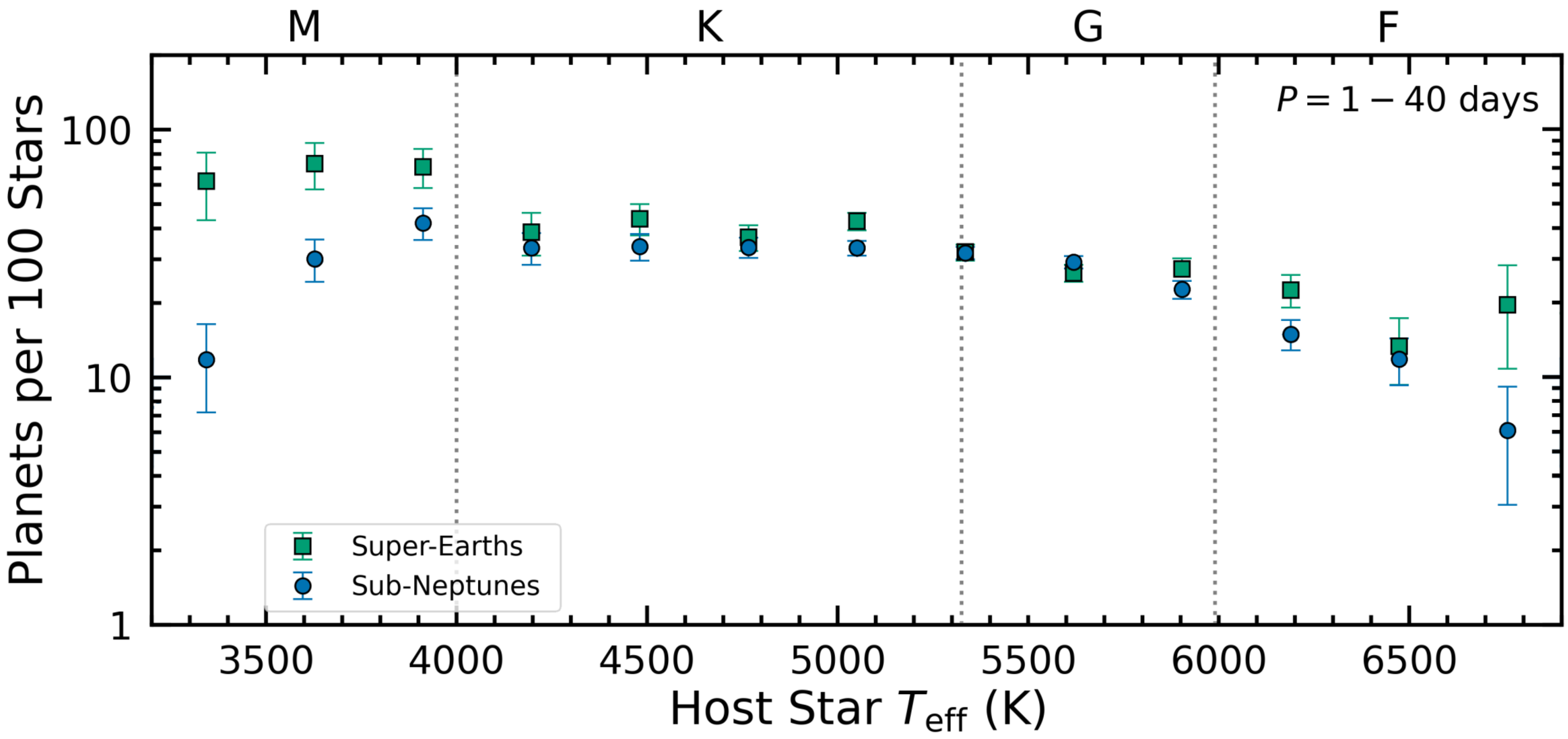


Previous analyses suggested comparable Super-Earth & Sub-Neptune occurrence rates for FGK stars



Scaling K2: Short-Period Sub-Neptune Occurrence Rates Peak Around Early-Type M Dwarfs
Kevin K. Hardegree-Ullman et al. (submitted)

Previous analyses suggested comparable Super-Earth & Sub-Neptune occurrence rates for FGK stars



Scaling K2: Short-Period Sub-Neptune Occurrence Rates Peak Around Early-Type M Dwarfs
Kevin K. Hardegree-Ullman et al. (submitted)

A Classification of the Architectures of Planetary Systems

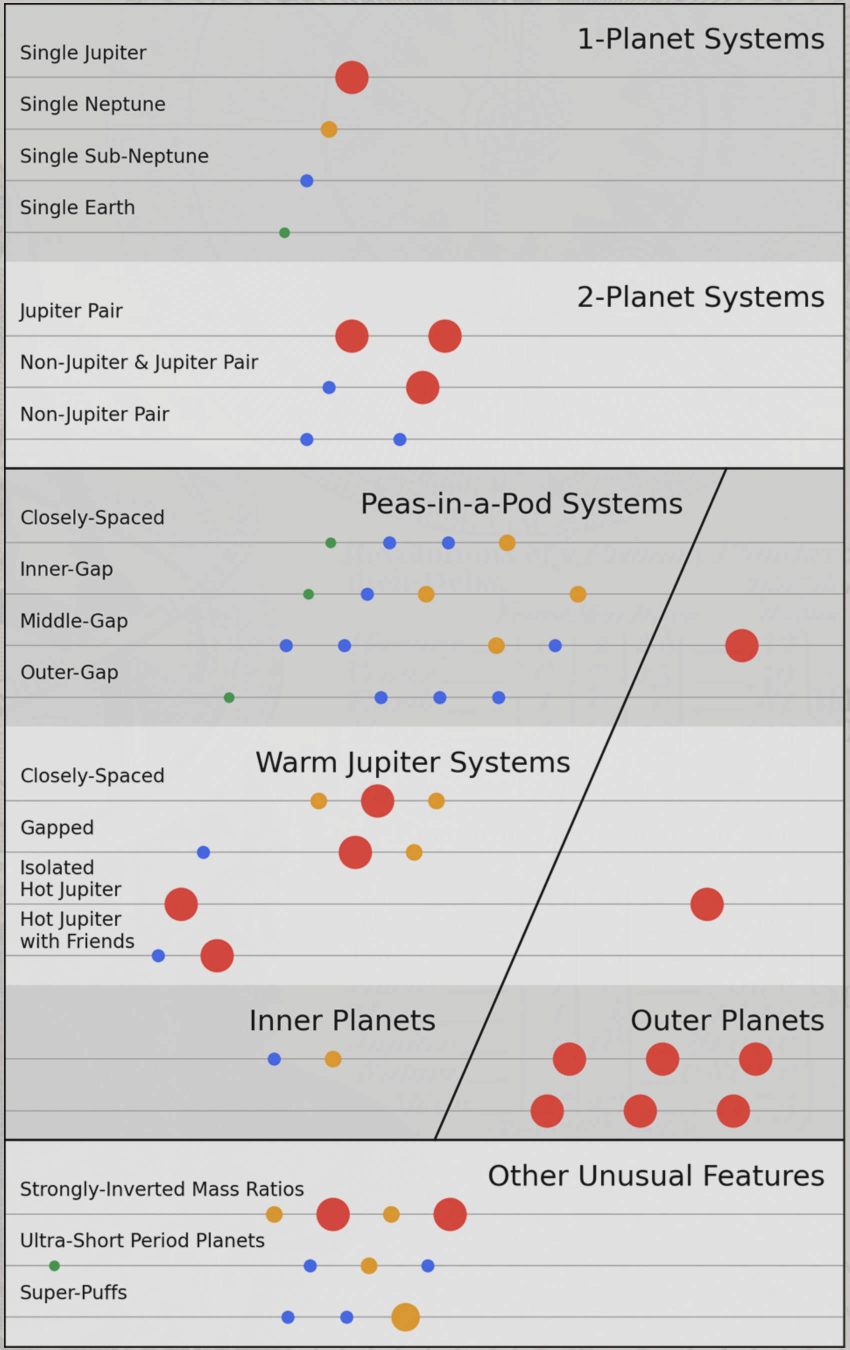
Alex Howe[1], Juliette Becker[2], & Fred Adams[3]

[1]Catholic University of America/NASA Goddard, [2]University of Wisconsin-Madison, [3]University of Michigan

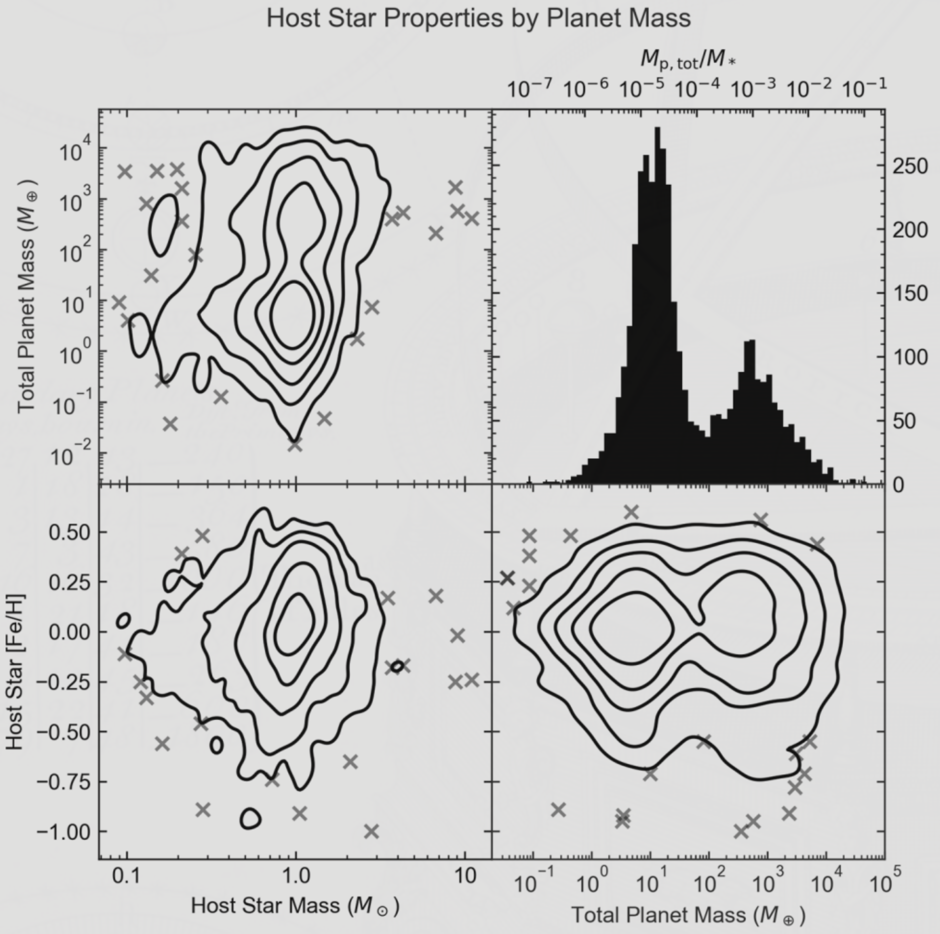
- The census of exoplanets has reached the point where it is both feasible and useful to classify planetary systems as distinct astrophysical objects.

- We present a classification framework based on a complete survey of the NASA Exoplanet Archive.

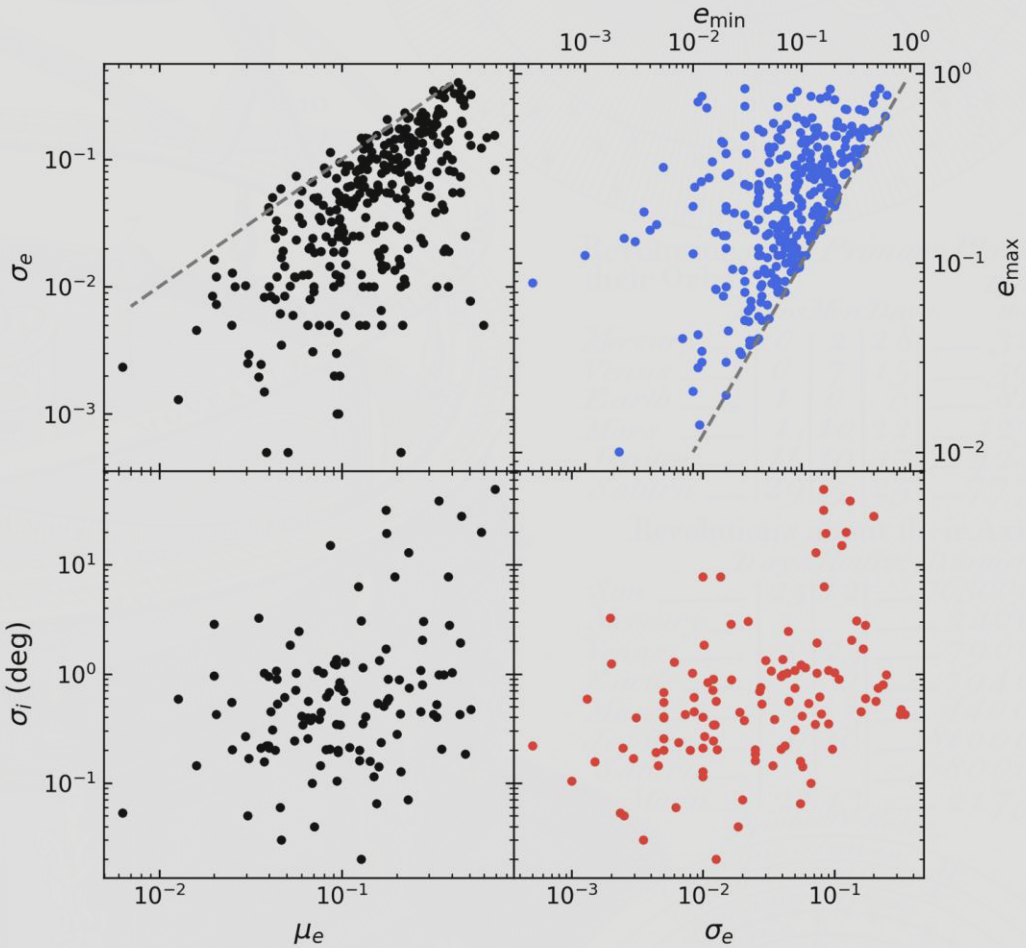
- Howe, Becker, Stark, & Adams, *AJ* **169**, 149



Ongoing Work



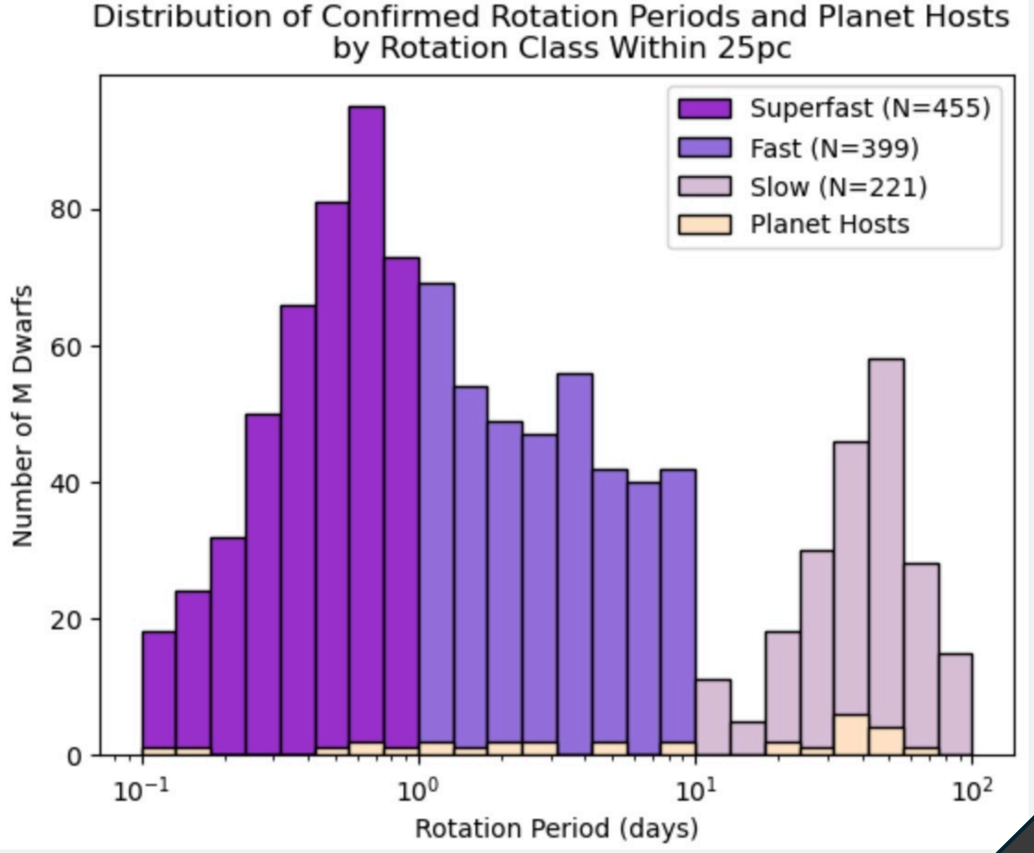
Paper II: host star properties, submitted to *PASP.*



Paper III: eccentricities and inclinations, in prep.

Is M Dwarf Rotation Rate a Clue to Planetary Presence?

Karina Kimani-Stewart
Georgia State University, RECONS Institute


Distribution of Confirmed Rotation Periods and Planet Hosts
by Rotation Class Within 25pc
Superfast (N=455)
Fast (N=399)
Slow (N=221)
Planet Hosts
Number of M Dwarfs
Rotation Period (days)
0
20
40
60
80
10^{-1}
10^{0}
10^{1}
10^{2}

1.7%

2.7%

6.0%


Coming soon...
Number of M Dwarfs
30
25
20
15

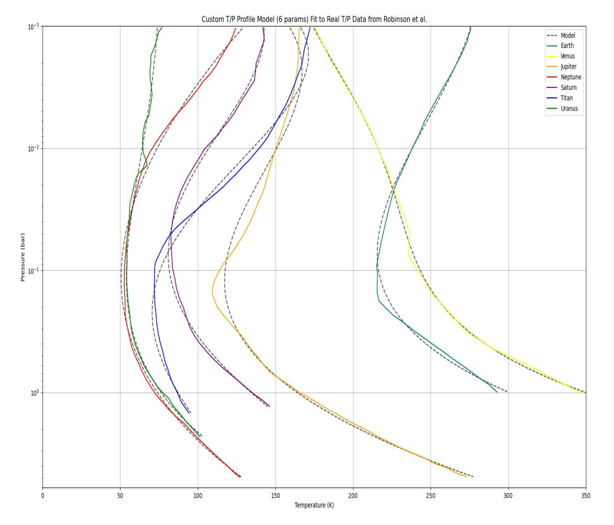
Cerberus: Modeling the Atmospheric Composition of Exoplanets for ARIEL/CASE

Luke Lamitina, Gael Roudier, Mark Swain, Excalibur Collaboration
NASA Jet Propulsion Laboratory, California Institute of Technology

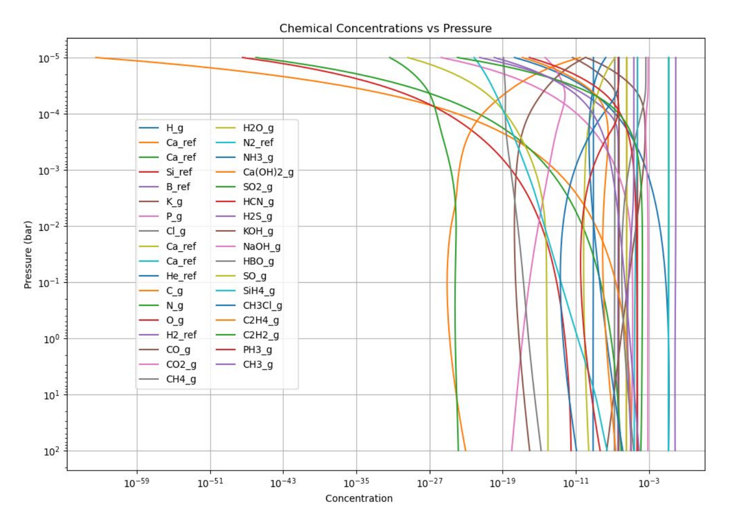
JPL
Jet Propulsion Laboratory
California Institute of Technology

Cerberus is the atmospheric forward model of Excalibur, a pipeline that will be used to conduct atmospheric retrievals for the ARIEL/CASE mission. Model improvements:

1. Variable Temperature-Pressure Profiles

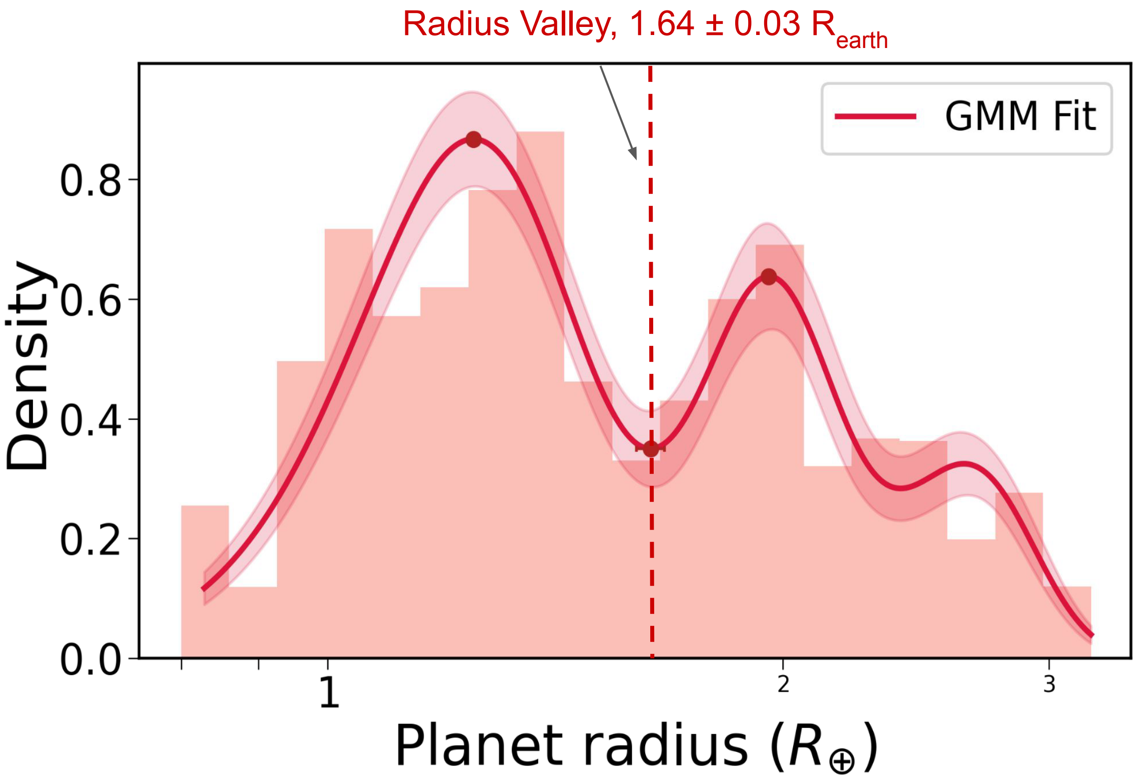


2. Thermodynamic Equilibrium Chemical Model



Exploring the Radius Valley among the lowest mass stars with TESS

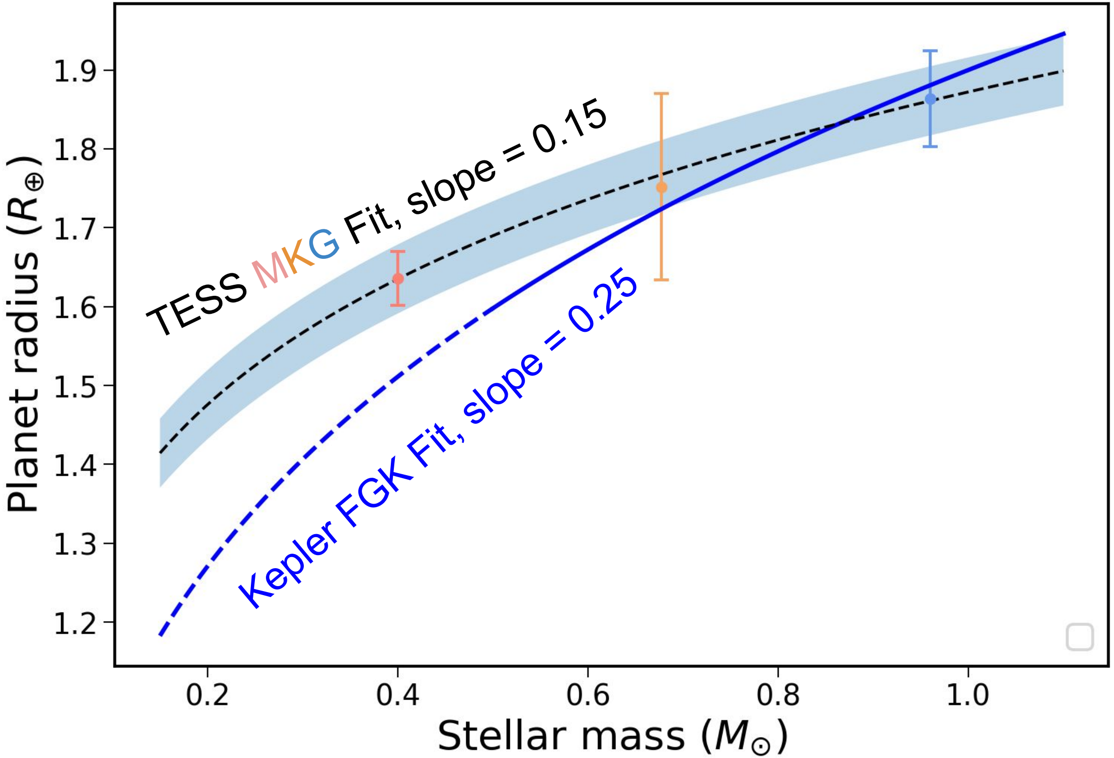
Harshitha M Parashivamurthy, Gijs D Mulders



- We found a radius valley among TESS M dwarfs.
- Fit a GMM curve to quantify the location of the radius gap.
- Repeated the process for G and K dwarfs as well.

Exploring the Radius Valley among the lowest mass stars with TESS

Harshitha M Parashivamurthy, Gijs D Mulders



- The radius valley among low-mass stars shifts to the right with increasing stellar mass.
- The observed fit is compared with the Wu (2019) scaling (solid blue line), which was derived from the Kepler FGK sample. The extrapolation to M dwarfs is indicated by the dashed blue line.

Astronomía
FACULTAD DE CIENCIAS FÍSICAS Y MATEMÁTICAS UNIVERSIDAD DE CHILE
INSTITUTO MILENIO DE ASTROFÍSICA

ExoClass: Coding the Chaos of Exoplanets

Mass of the exoplanets
(Units of mass)

M – Mercury (less than $1.3 \cdot 10^{24}$ kg)
mass less than 0.0007 M_{Jup} (0.22 M_{Earth})
E – Earth (from $1.3 \cdot 10^{24}$ kg to $1.3 \cdot 10^{25}$ kg)
mass from 0.0007 M_{Jup} to 0.007 M_{Jup}
(from 0.22 M_{Earth} to 2.2 M_{Earth})
S – SuperEarth or SubNeptune
(from $1.3 \cdot 10^{25}$ kg to $1.3 \cdot 10^{26}$ kg)
mass from 0.007 M_{Jup} to 0.07 M_{Jup}
(from.2.2 M_{Earth} to 22 M_{Earth})
N – Neptune (from $1.3 \cdot 10^{26}$ kg to $7.6 \cdot 10^{26}$ kg)
mass from 0.07 M_{Jup} to 0.4 M_{Jup}
(from 22 M_{Earth} to 127 M_{Earth})
J – Jupiter (from $7.6 \cdot 10^{26}$ kg to $2.7 \cdot 10^{28}$ kg)
mass from 0.4 M_{Jup} to 14 M_{Jup}
(from. 127 M_{Earth} to 4450 M_{Earth})
D – Dwarf (more than $2.7 \cdot 10^{28}$ kg)
mass more than 14 M_{Jup} (4450 M_{Earth})

Eccentricity

used only to the first decimal position of the value of eccentricity, which is mathematically rounded

EG0t (Venus)

Mean Dyson temperature (MDT)
(Mean Orbit temperature)

F - Freezing MDT is less than 250K
W - Water MDT from 250 to 450K
G - Gaseous MDT from 450 to 1000K
R - Roaster MDT greater than 1000K
P - Pulsar class for planet orbiting Plusar stars

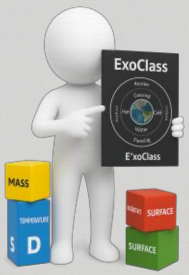
Surface attribute
(Bulk density)

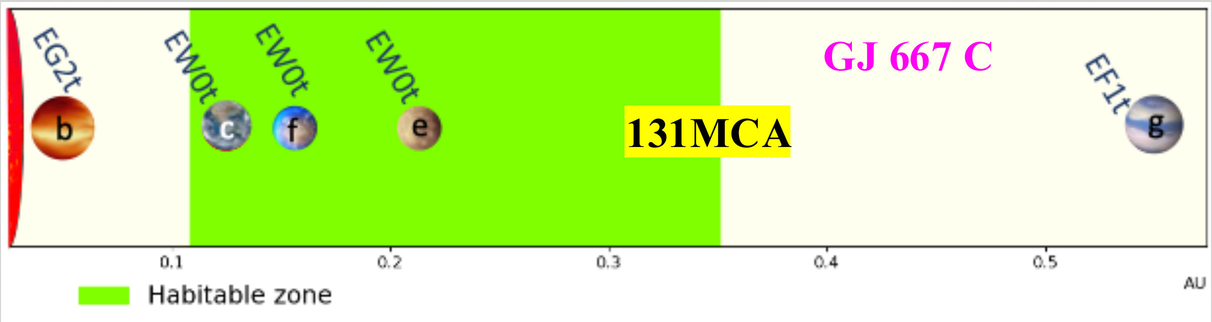
g – Gaseous planet
bulk density less than 0.25 g/cm^3
w – Water planet
bulk density from 0.25 to 2 g/cm^3
t – Terrestrial planet
bulk density from 2 to 6 g/cm^3
i – Iron planet
bulk density from 6 to 13 g/cm^3
s – Super dense planet
bulk density more than 13 g/cm^3

What does “super-Earth” mean? Not much.

ExoClass encodes planets using 4 physical parameters: mass, temperature, eccentricity, and surface.

Example: Earth → *EW0t*





Visit Eva Plávalová poster

System architecture - position
Zone index
Numbers of the planets in hot zone, habitable zone and cold zone

Stellar component
A, B, C, D ... or X for single star

224GXO (Solar system)

Harvard spectral classification

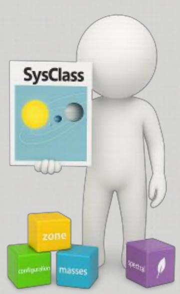
System architecture - mass
Mass distribution
O – ordered
A – anti-ordered
M – mixed
S – similar

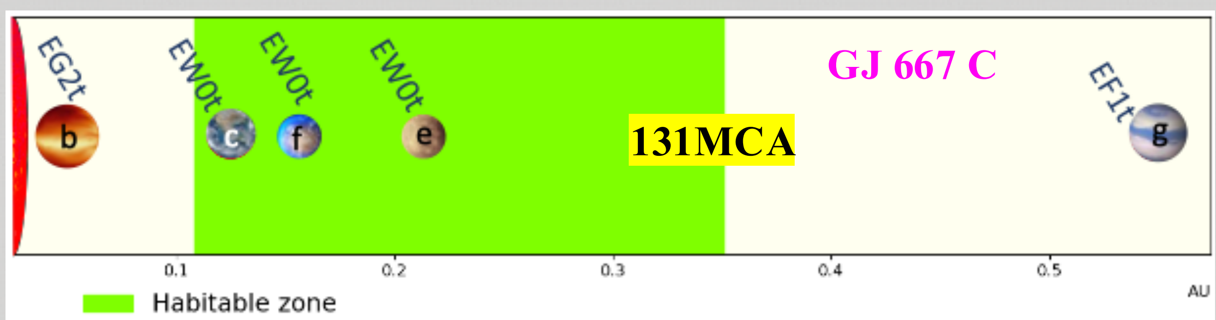
Too many orbits, too little structure? Try SysClass.

224GXO – that's the Solar System in SysClass.

We classify planetary systems using zone distribution, stellar type, and mass layout.

Clear, compact, and comparable.





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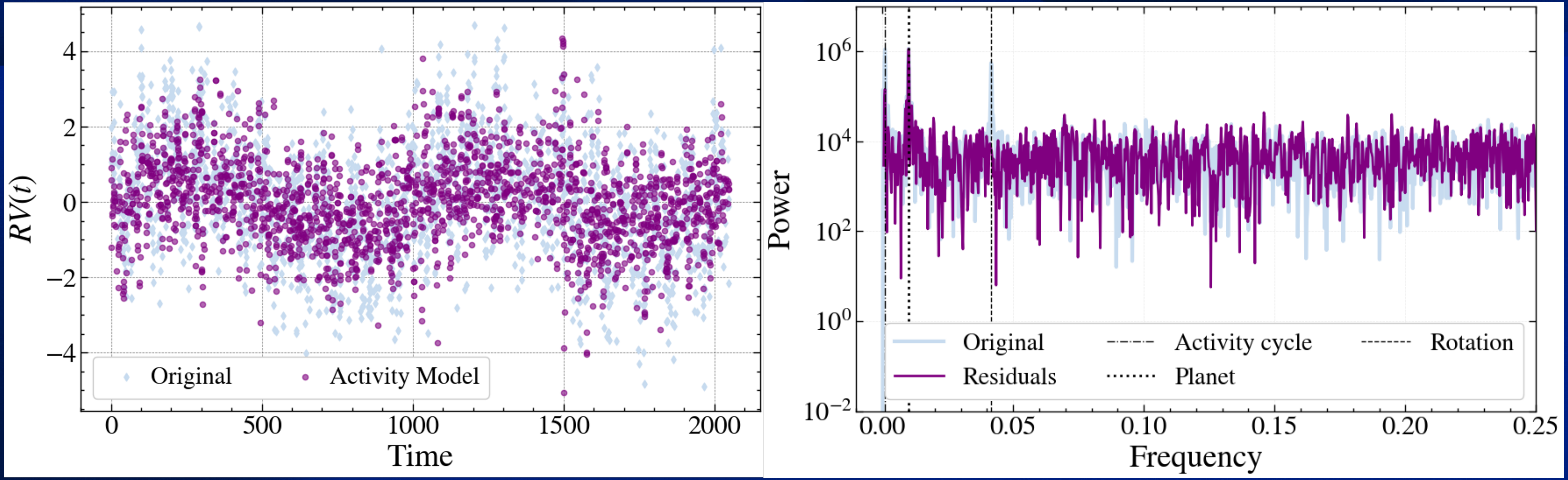
Frequency-Domain Activity Correction (fdac)

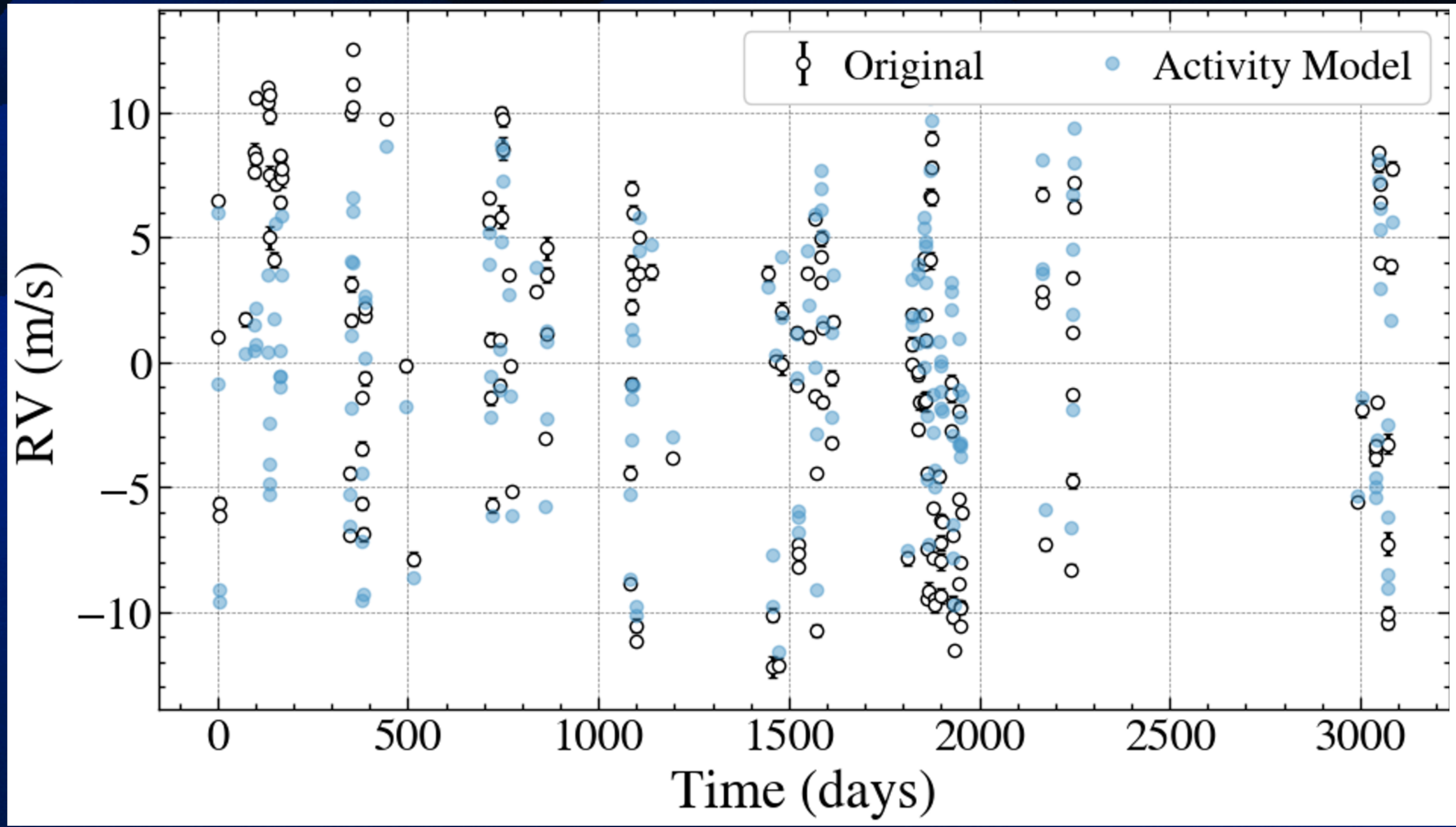
- Search for Earth-like exoplanets in radial velocities surveys.
- Python package to model stellar activity signals using multiple linear regression in the frequency domain.
- Poster highlights our result on synthetic data and archival RVs.

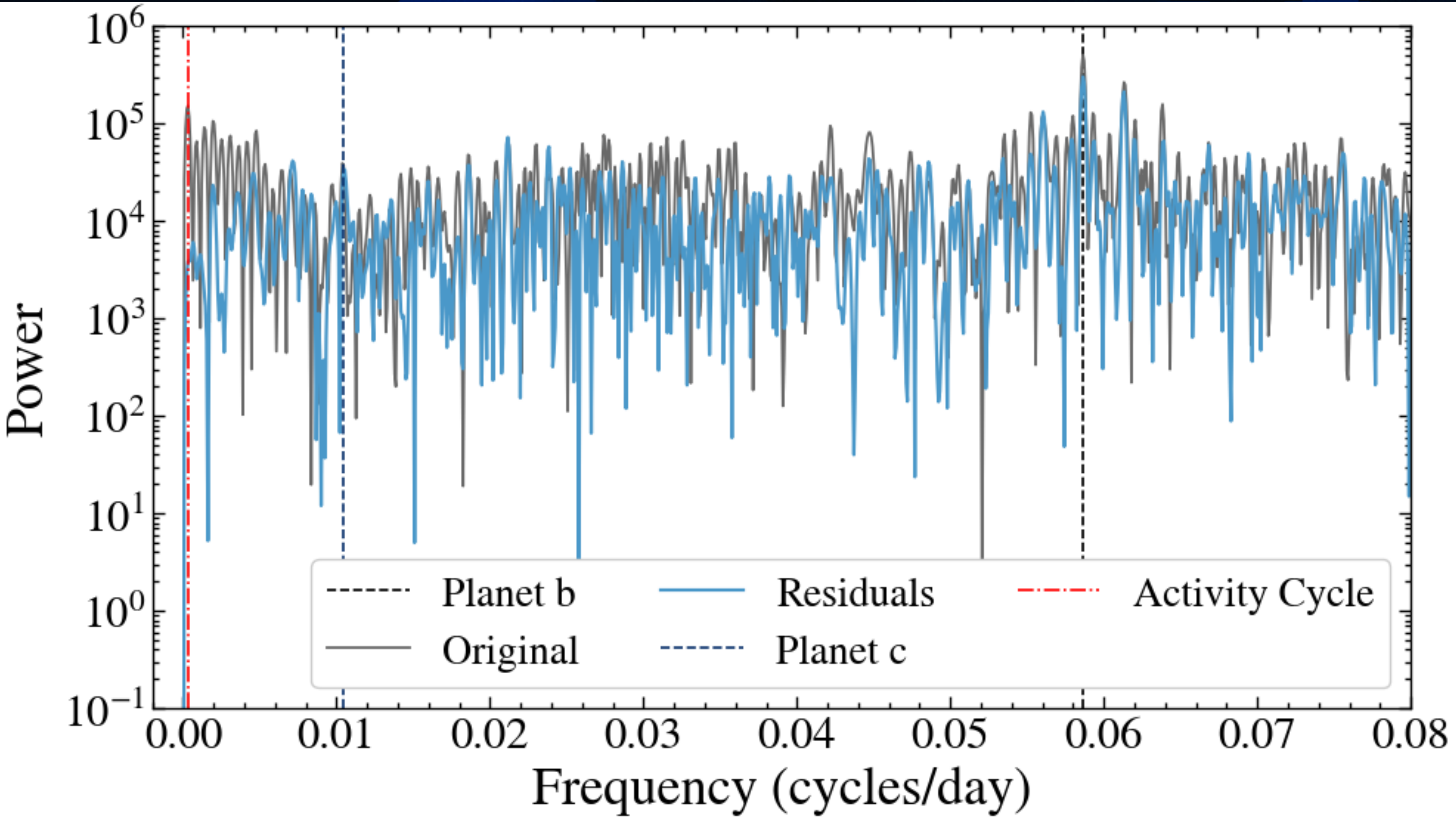


Victor Ramirez Delgado
vicrld@udel.edu
vicaleram.github.io
University of Delaware

HD 99492 Results

- Applied fdac to HD 99492 HARPS-N data set.
- Goal is to subtract the stellar activity without removing the planet signals.





Victor Ramirez Delgado
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A Bayesian approach to assessing the sensitivity of detecting planets in photometric data

Madison G. Scott
University of Birmingham

EXOPLANET DETECTION LIMITS

WOW! OCCURRENCE RATES!

NEW METHOD!

We want to measure the occurrence rates of exoplanets around late-type M dwarfs

We want to find out where our detection limit lies for a given photometric dataset

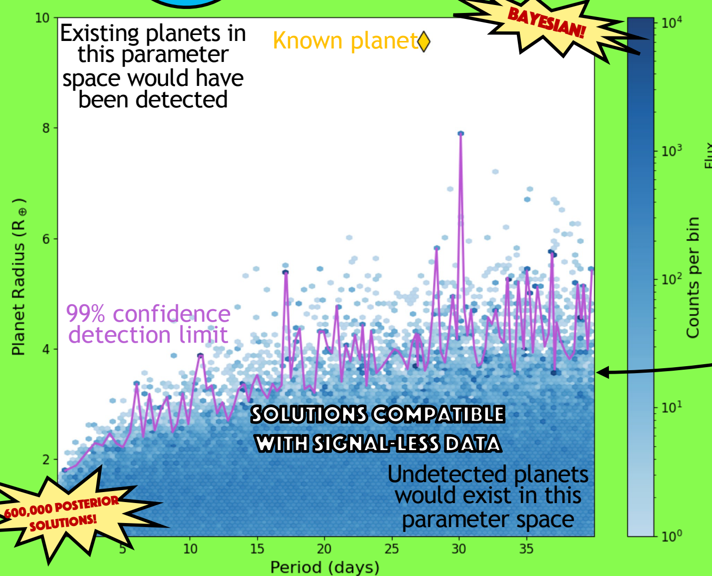
This will help inform occurrence rates by assessing our completeness using detection limits

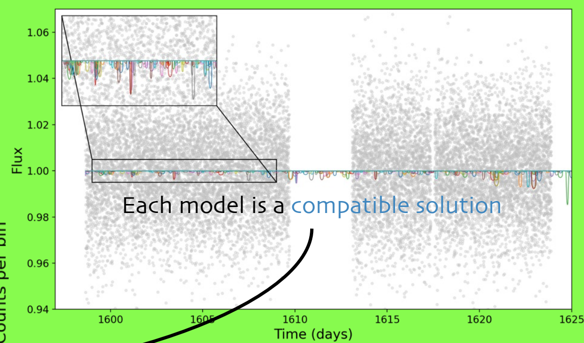
We are asking the question "What is compatible with the data?"

What remains formally undetected?

This is NOT injection recovery

BAYESIAN!





ADVANTAGES

COMPARED TO INJECTION RECOVERY

1. BAYESIAN
2. NON-DISCRETE SOLUTION GRID
3. 4 MORE PARAMETERS DRAWN FROM DISTRIBUTIONS
4. 100S-1000S MORE SOLUTIONS
5. ~20X FASTER

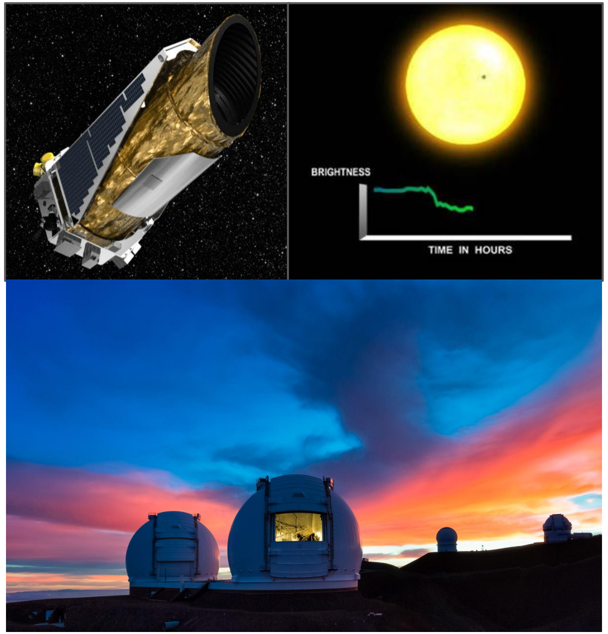
SCOTT, TRIAUD & DAVIES, IN PREP

UNIVERSITY OF BIRMINGHAM
UKRI Science and Technology Facilities Council
SPECULOOS

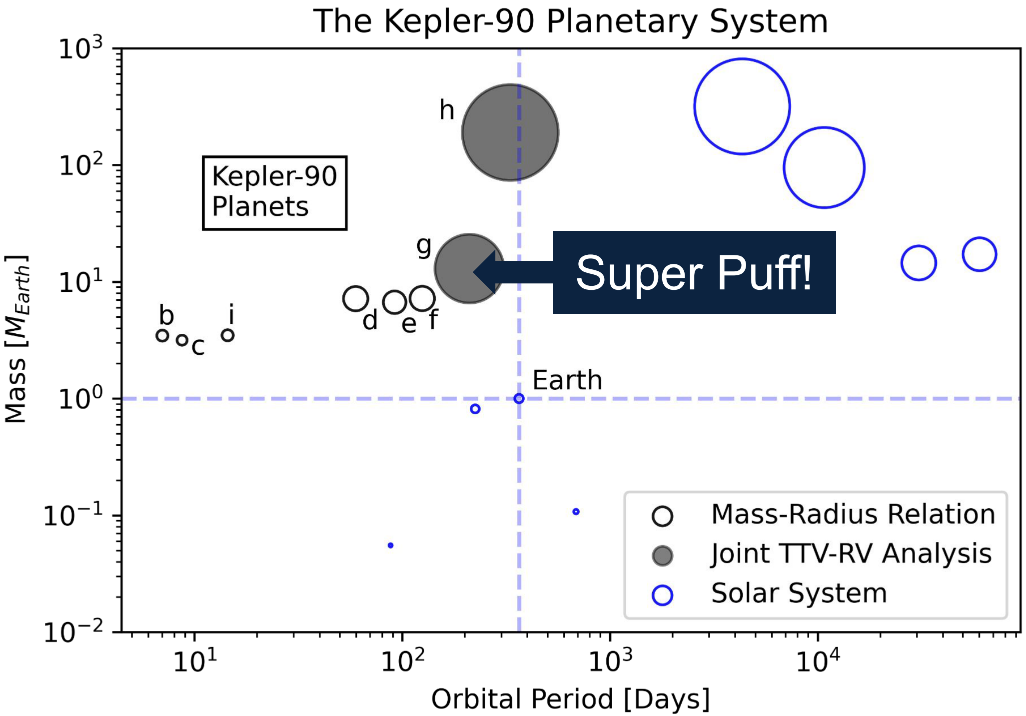
Updated Masses for Kepler-90's Gas Giants Via Transit-Timing Variation and Radial Velocity Observations

UNIVERSITY OF NOTRE DAME

David Shaw
dshaw2@nd.edu



NASA and W. M. Keck Observatory

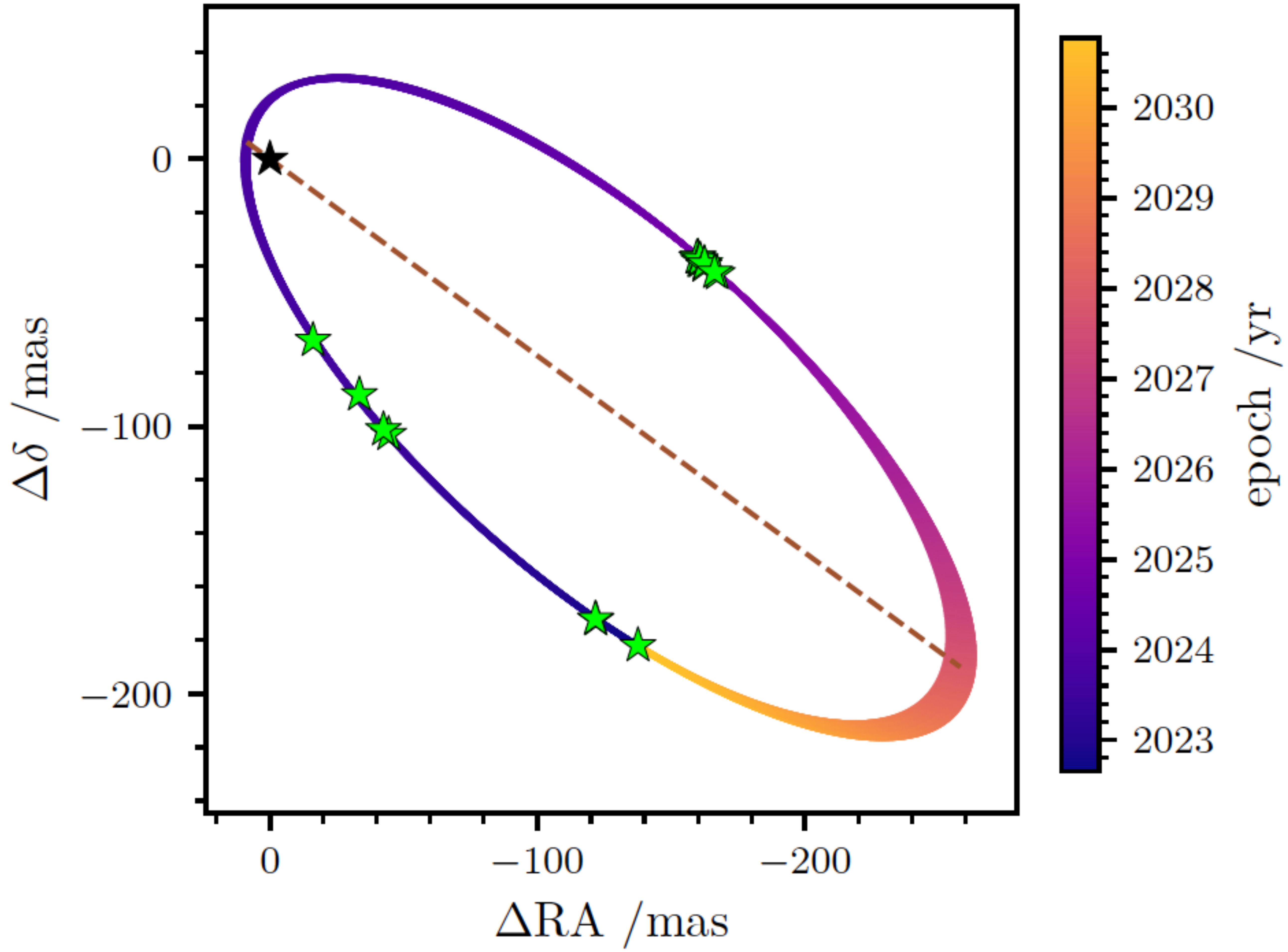


An eccentric stellar companion in the hot dust system κ Tucanae A

Thomas A. Stuber

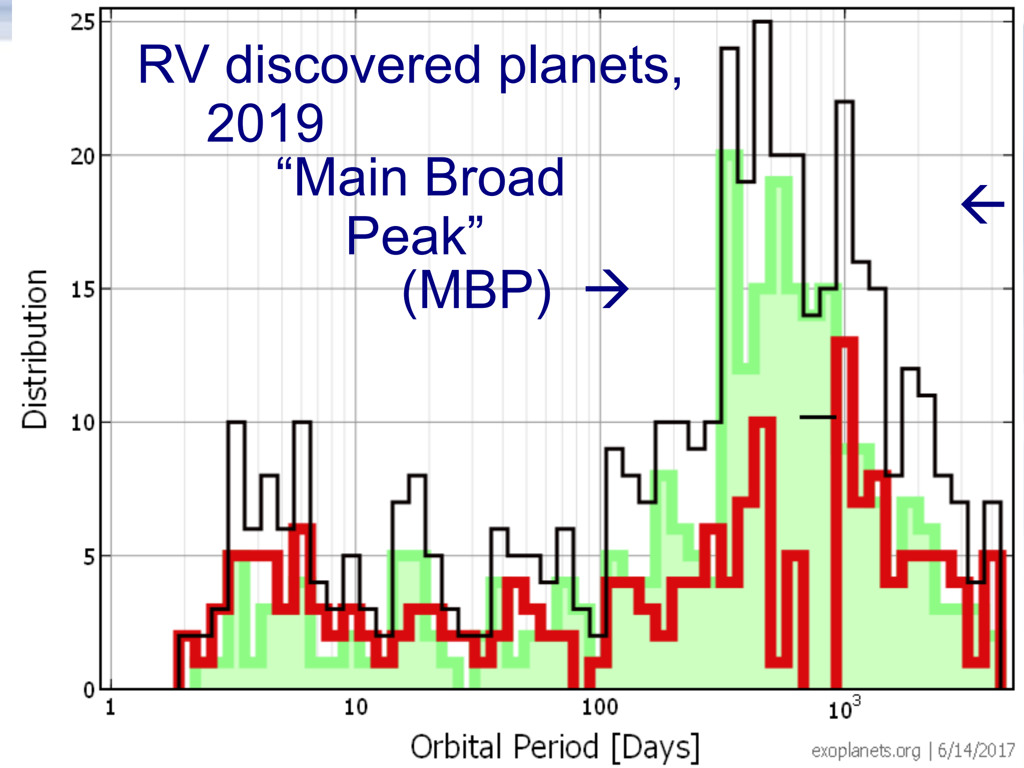
<u>Also talk to me about:</u>

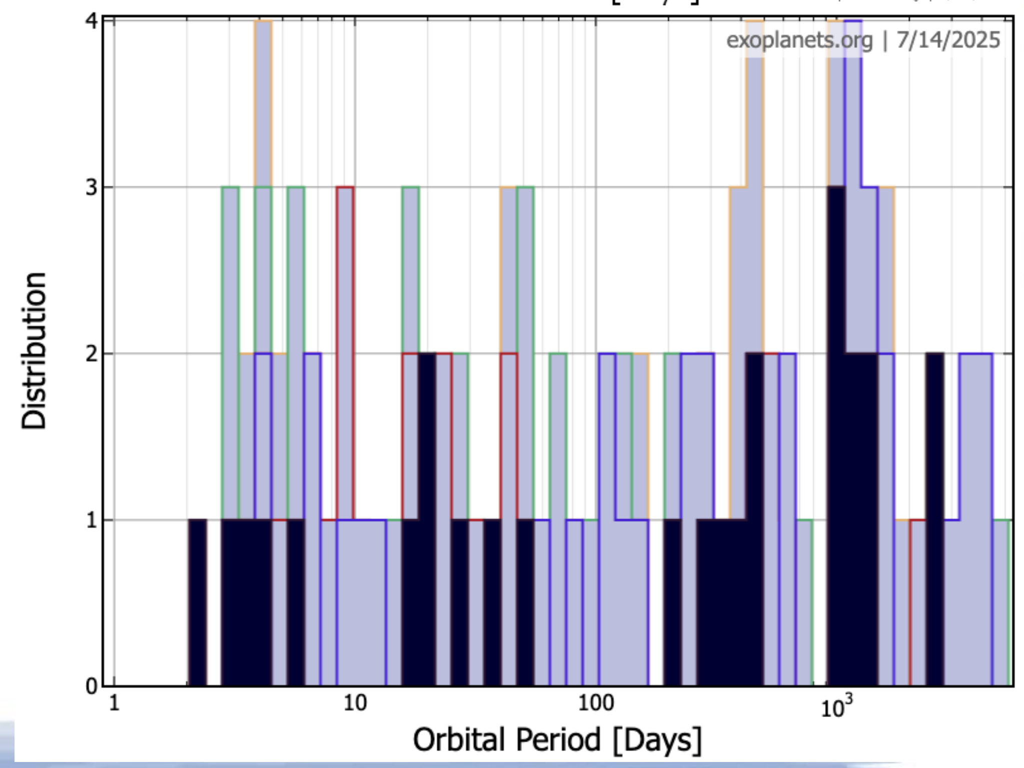
- **Hot exozodiacal dust**
- **Its impact on direct imaging**
- **Long-baseline interferometry**



tstuber@arizona.edu
Steward Observatory, The University of Arizona

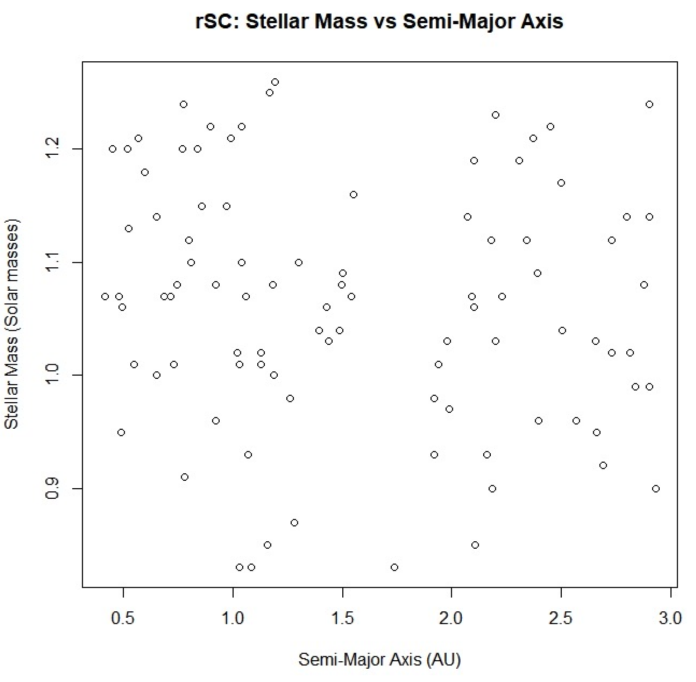
The Main Broad Peak: Characterizations and Features

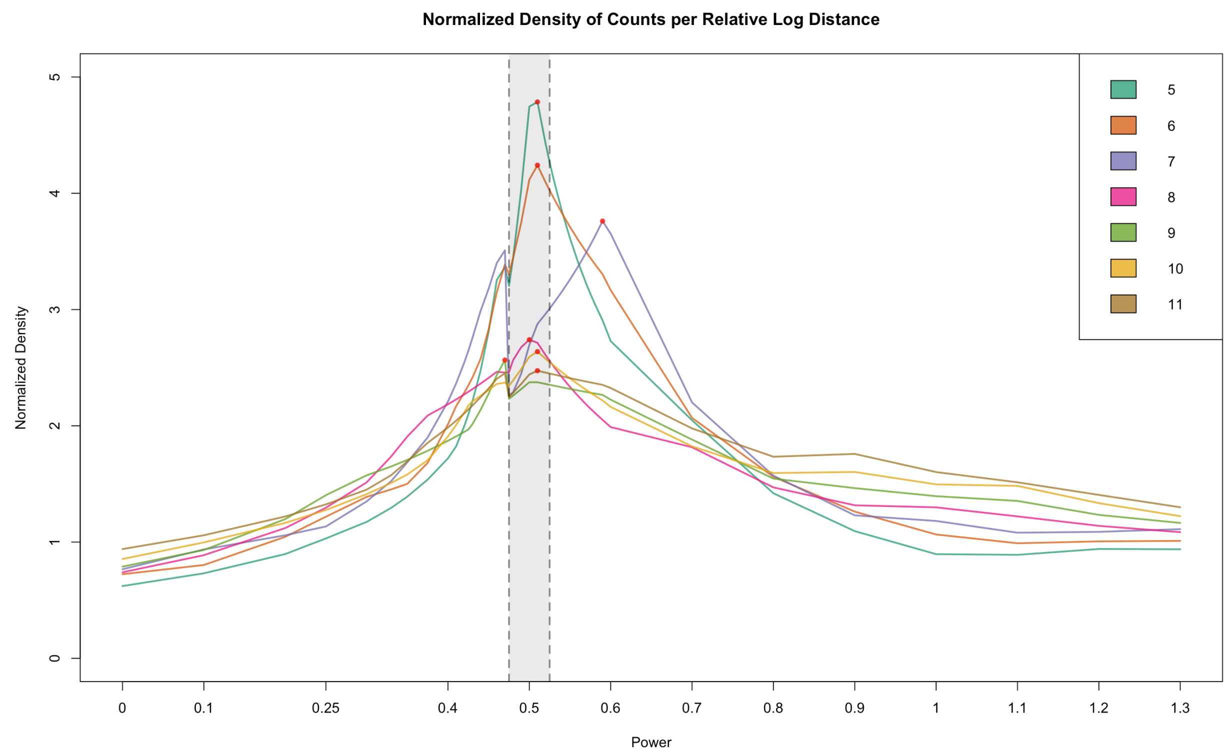




- The largest number of giant planets occur in a "Main Broad Peak" (MBP), at least for planets sufficiently large ("giant") to have been found by radial velocity (RV).
- We find the MBP changes with parameters of the star, planet, and orbit. We highlight the change in distance from the star and width with stellar mass (lower right)

Features of MBP: Density dependence on Stellar Mass of Peak-Gap-Peak (PGP)





In population of planets of metal rich stars most like sun, the MBP is split by a gap into two peaks.

We test that the semi-major axis *a* of the outer boundary of the gap (the boundary with the peak furthest from the star) scales with the square root of the stellar mass (left), by simulating that it is highly unlikely for this dependence to be random.

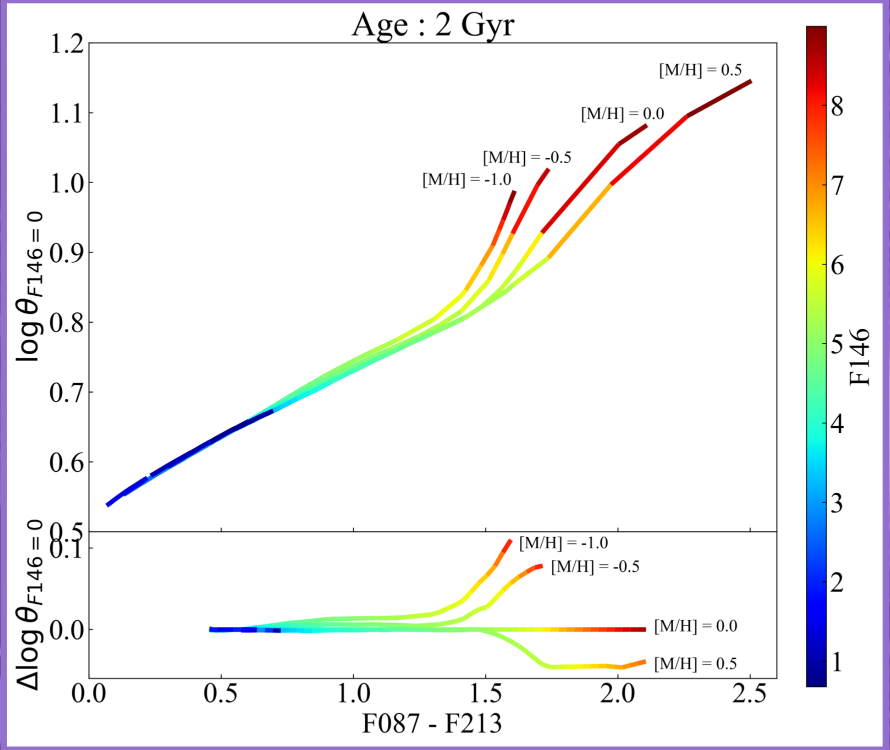
This is further evidenced by how the density in the region of the outer peak is found to reach a maximum next to the gap at a power *p* of the stellar mass M_{star}. This is found (right) when testing *a* adjusted by the stellar mass by a range of powers *p*, $a_{adj} = M_{star}^{p}$.

Surface Brightness Relations With The Nancy Roman Space Telescope

Emelly Tiburcio, Matthew Penny, Tabetha Boyajian

LSU Department of Physics & Astronomy

- Surface brightness relations (SBRs), along with mass–magnitude and mass–color relations, are critical tools for estimating lens masses in microlensing studies.
- SBRs connect a star's color and magnitude to its angular diameter.
- This is key for microlensing events with finite source effects, enabling planet mass measurements.
- Ground-based microlensing typically targets FGK stars, where SBRs are tight and reliable.
- Roman Space Telescope will push to fainter, redder M dwarfs, where:
  - SBRs show more scatter
  - Metallicity effects become significant
- This shift challenges existing SBR assumptions and motivates the need for better calibrations in the M-dwarf regime.



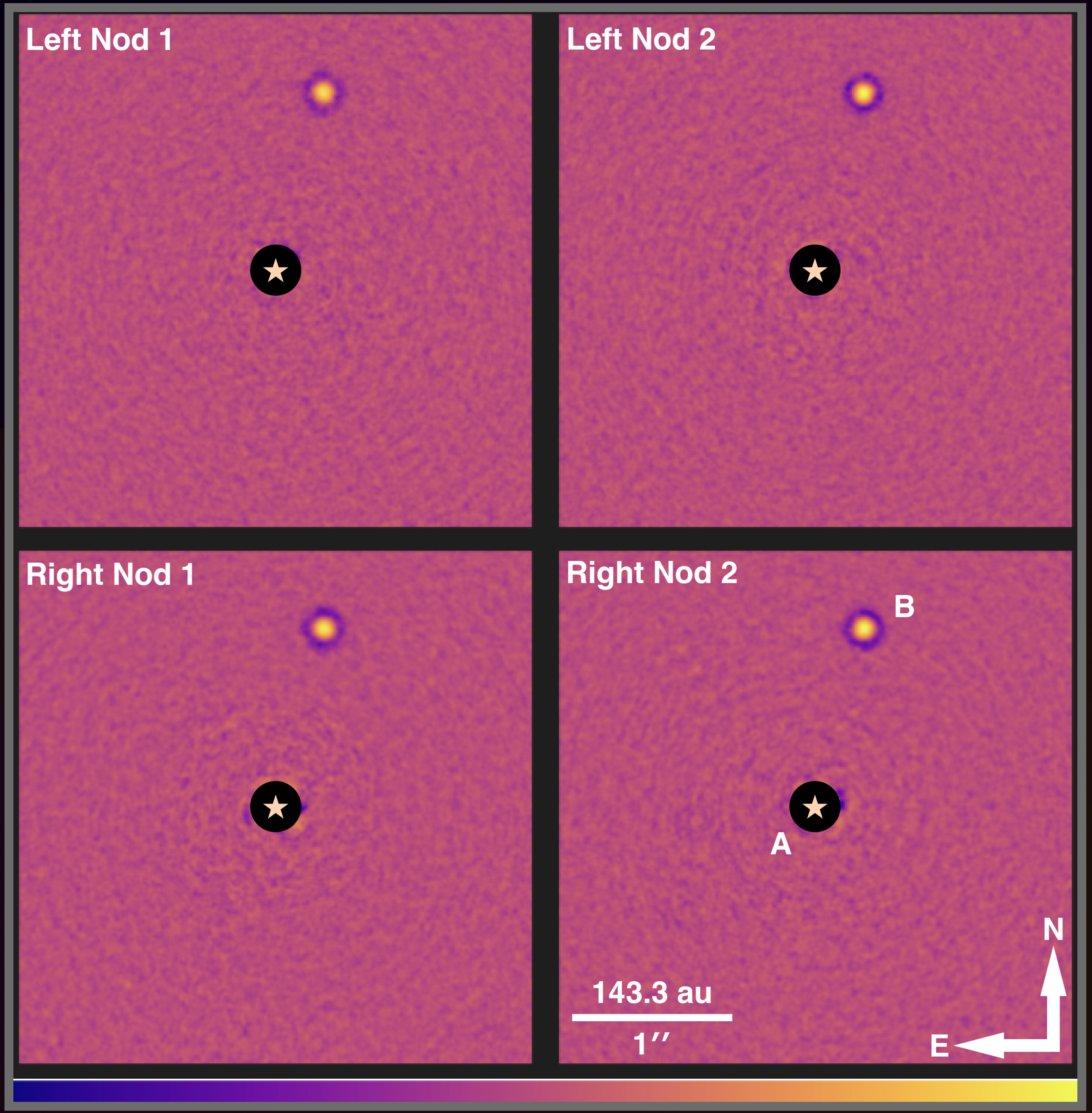
Want to find out how we deal with that?

See my poster!

Mid-IR High-Contrast Imaging w/LBTI at > 100 Myr

Gabriel Weible, Astronomy & Astrophysics Ph.D. Student
University of Arizona
gweible@arizona.edu

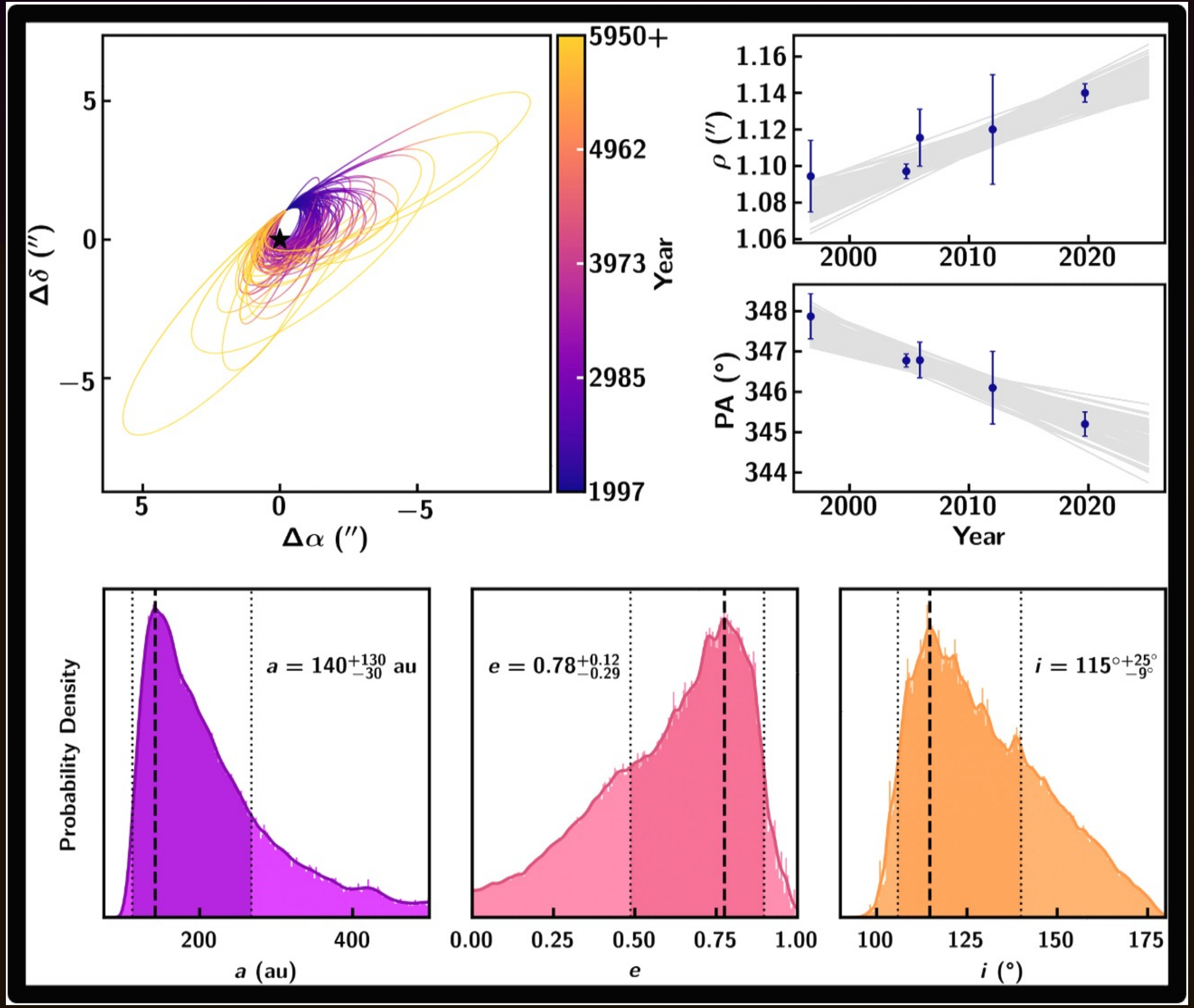
LBTI/LMIRCam L' Imaging (09/2019)



Weible, Wagner, Stone et al. (2025)

HII 1348B

- **~60 M_{Jup}** companion to a K-type SB2 Star in the Pleiades
- **Pleiades aged ~112 Myr**
- 2 telescope apertures, 2 nodding positions $\Longrightarrow$ **4 semi-independent observations**
- Astrometry $\Longrightarrow$ orbital modeling (*Weible et al. 2025*)



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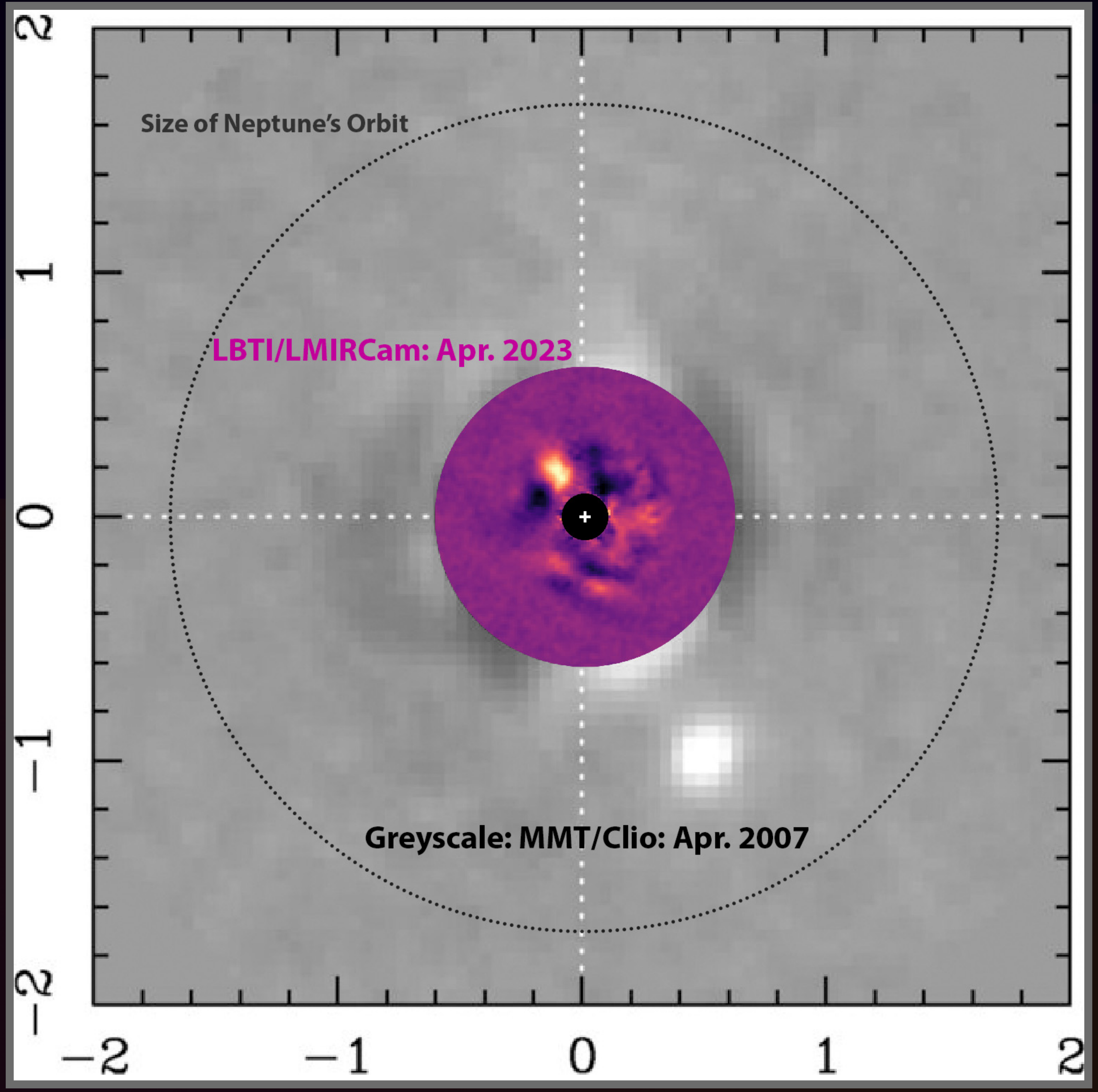
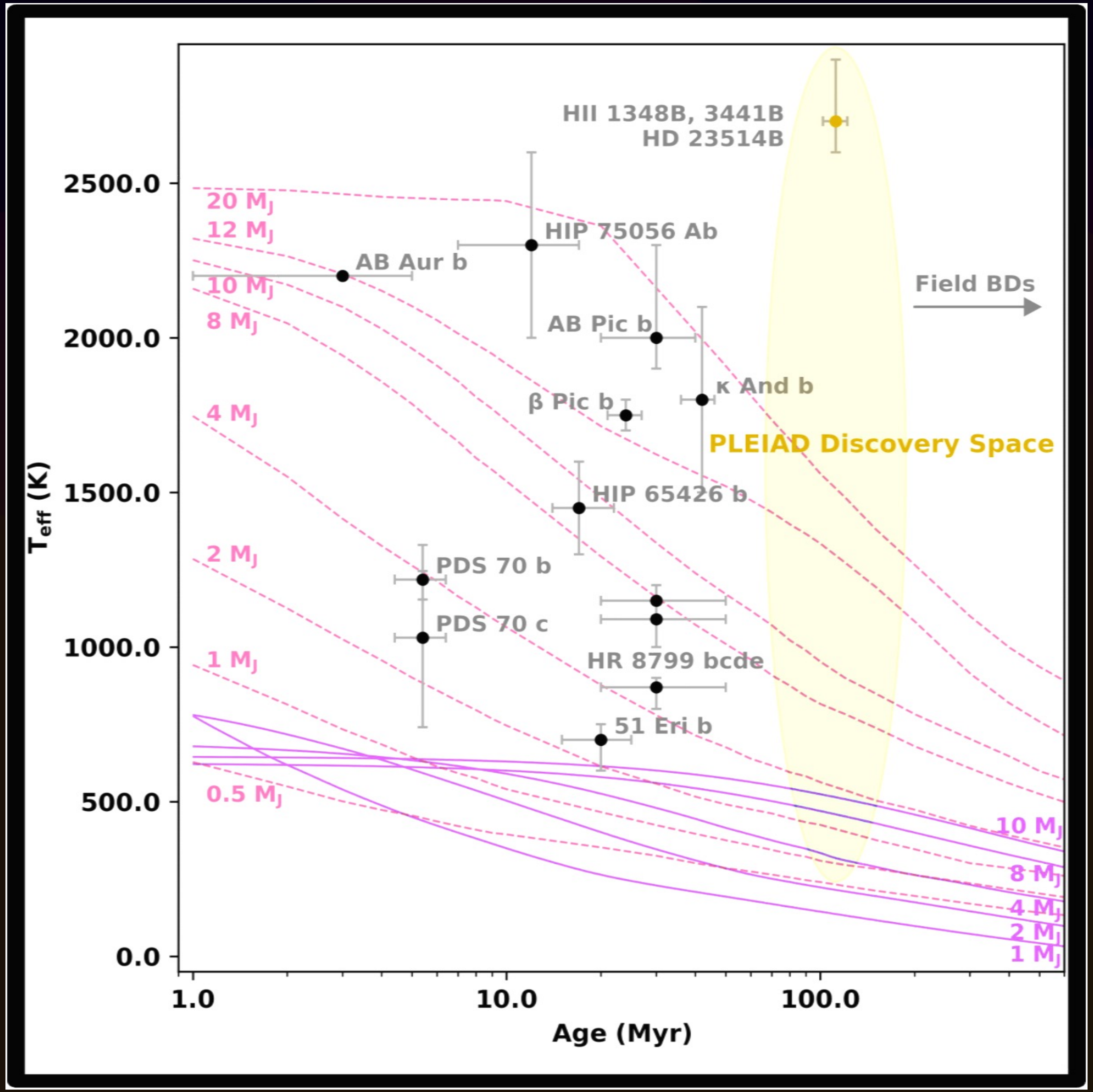


Mamajek et al. 2010, Weible et al. in prep.

Alcor B

- ***M*-Band (~4.8 μm) LBTI/LMIRcam direct imaging** (*Weible et al., in prep*)
- 2023 separation is < 0.25" (< 2 λ/D)
- **Significant orbital motion over 16 years to be investigated**

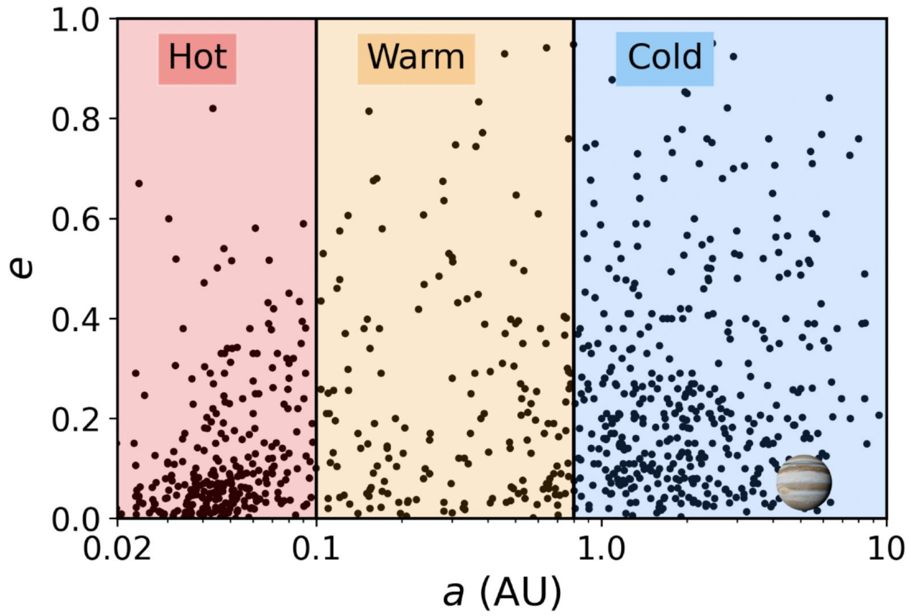
+ a proposed survey of accelerating Pleiades stars…



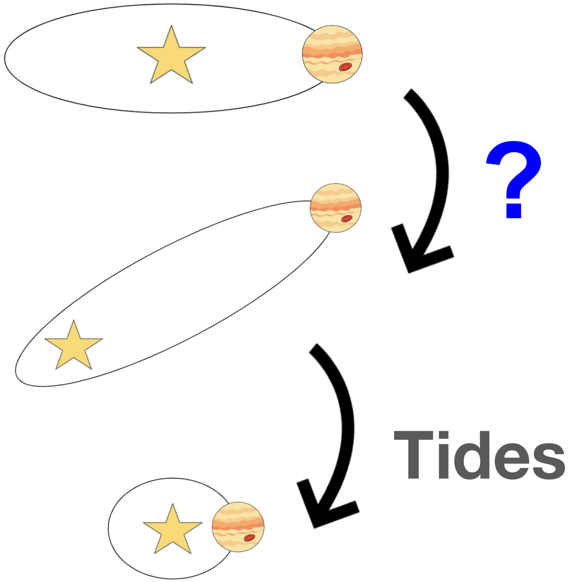
The Stellar Eccentric Kozai-Lidov Mechanism as a Key Driver of Cold Jupiter Eccentricities

Grant Weldon, Smadar Naoz, Brad Hansen

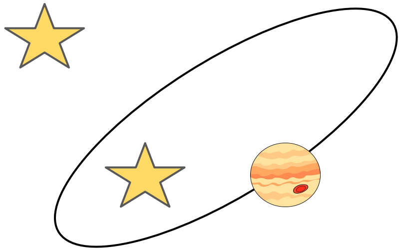
UCLA

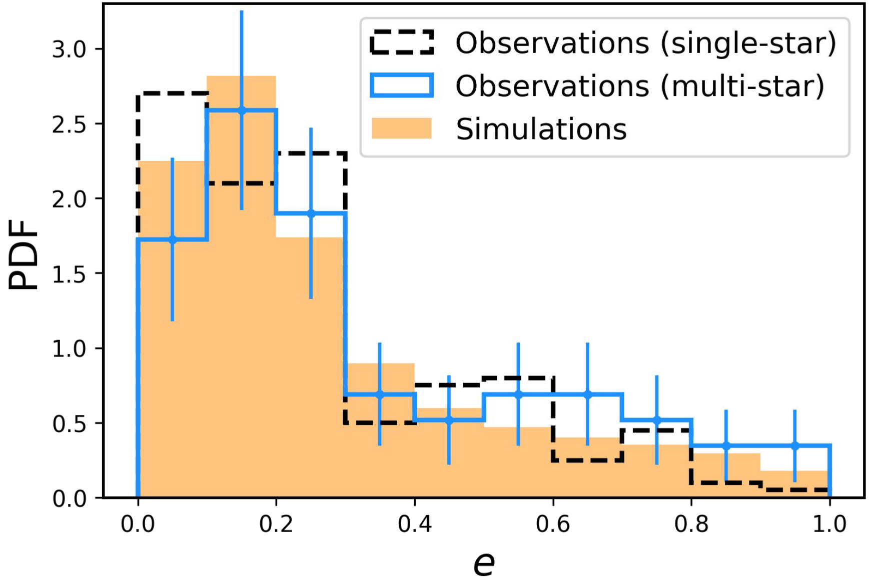


Weldon et al 2025 (data from NASA Exoplanet Archive)



Stellar companions can excite planetary eccentricities via the Eccentric Kozai-Lidov (EKL) mechanism





Statistical agreement between dynamically simulated population with scattering+stellar EKL and observed eccentricity distribution of cold Jupiters

Weldon et al 2025
ApJ Letters