



Astrophysical Parameters of **Sexy** Exoplanet Host **Stars** Plus Associated Consequences

Kaspar von Braun
&

T. S. Boyajian, G. T. van Belle, D. R. Ciardi, M.
Lopez-Morales, H. A. McAlister, T. Henry, S. R.
Kane, C. Farrington, P. J. Goldfinger, G. Schaefer,
T. A. ten Brummelaar, S. Ridgway, L. Sturmann,
J. Sturmann, N. H. Turner, A. F. Boden





MOTIVATION

- Fundamental Astrophysical Parameters ...
 - Luminosity = f (radius, temperature) = f (θ , distance, F_{BOL})
 - Habitable Zone = f (Luminosity)
- ... for Sexy Exoplanet Host Stars... 
- ... Plus Associated Consequences
 - Study the primary energy source of the system (host star)
 - Radiation environment & habitable zone
 - Constraints on planetary formation, evolution
- **Astrophysical Parameters of the PLANET**





Methods (stellar R & T_{EFF}, HZ)

- CHARA Classic
 - H -band (1.67 micron)
 - Longest available baselines (> 300 m)
 - Distance from parallax measurements.
- Literature Photometry and Spectral Templates
 - Pickles (1998) templates
 - SEDfit code (A. Boden): $T_{\text{EFF}} = f(F_{\text{BOL}}, \theta)$
 - HZ boundaries: Jones & Sleep (2010)





FEATURING...

○ In a Leading Role

- **GJ 581** (with 4/6 planets, some of which are in the Habitable Zone)
- **GJ 436** (with a transiting planet)

○ In a Supporting Role

- **GJ 614**
- **GJ 649**

○ In a Future Role

- **GJ 876** (multiplanet system)





GJ 581 – Background

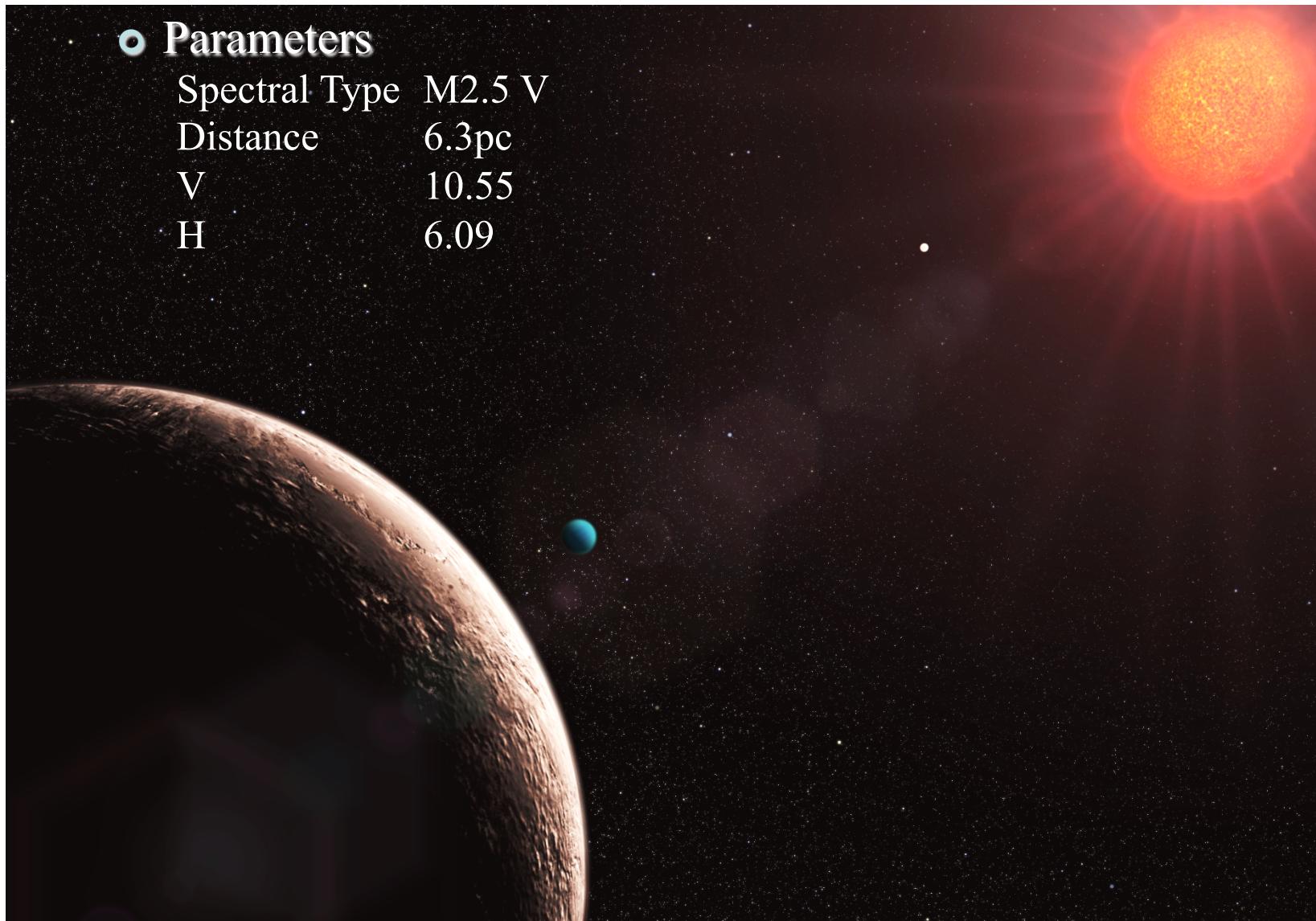
● Parameters

Spectral Type M2.5 V

Distance 6.3pc

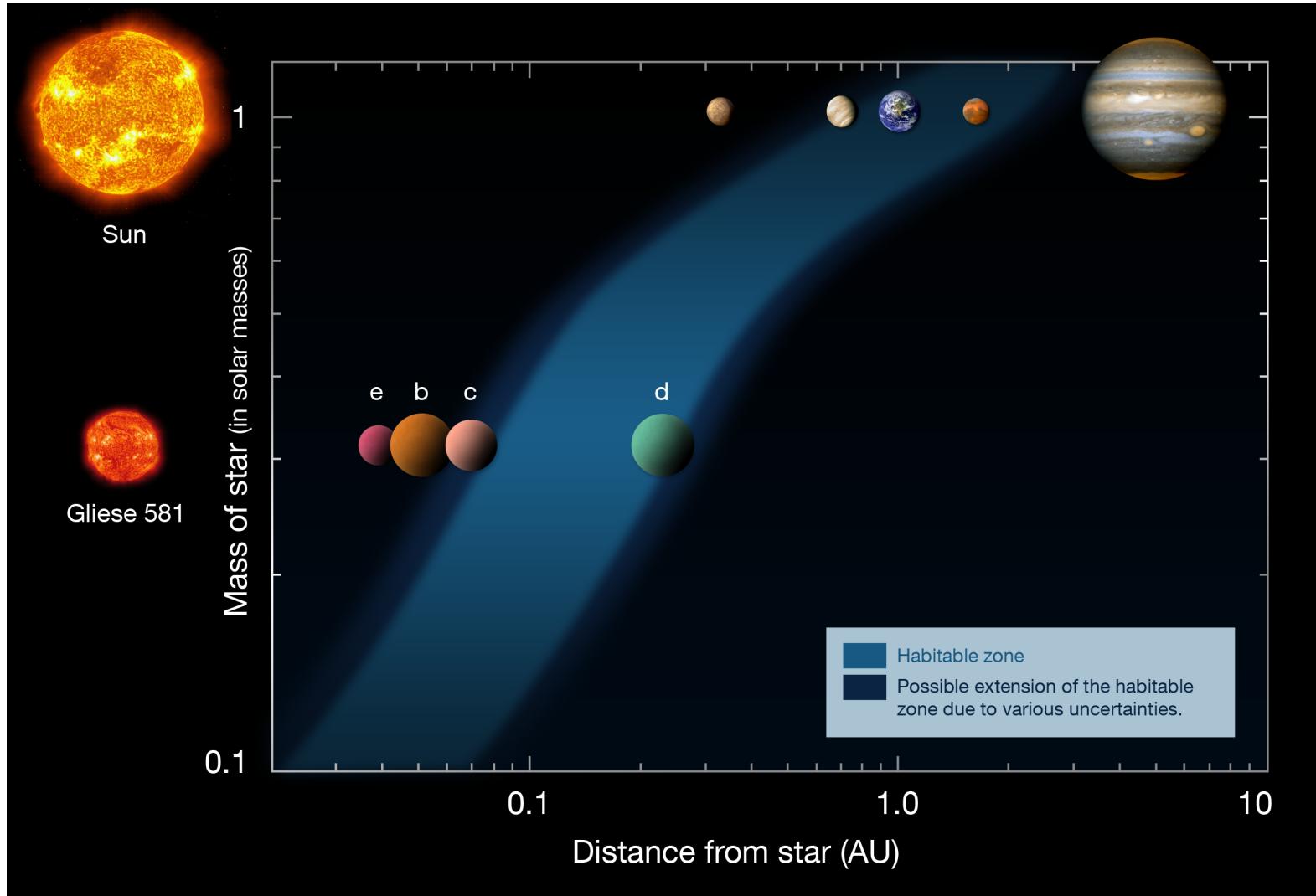
V 10.55

H 6.09





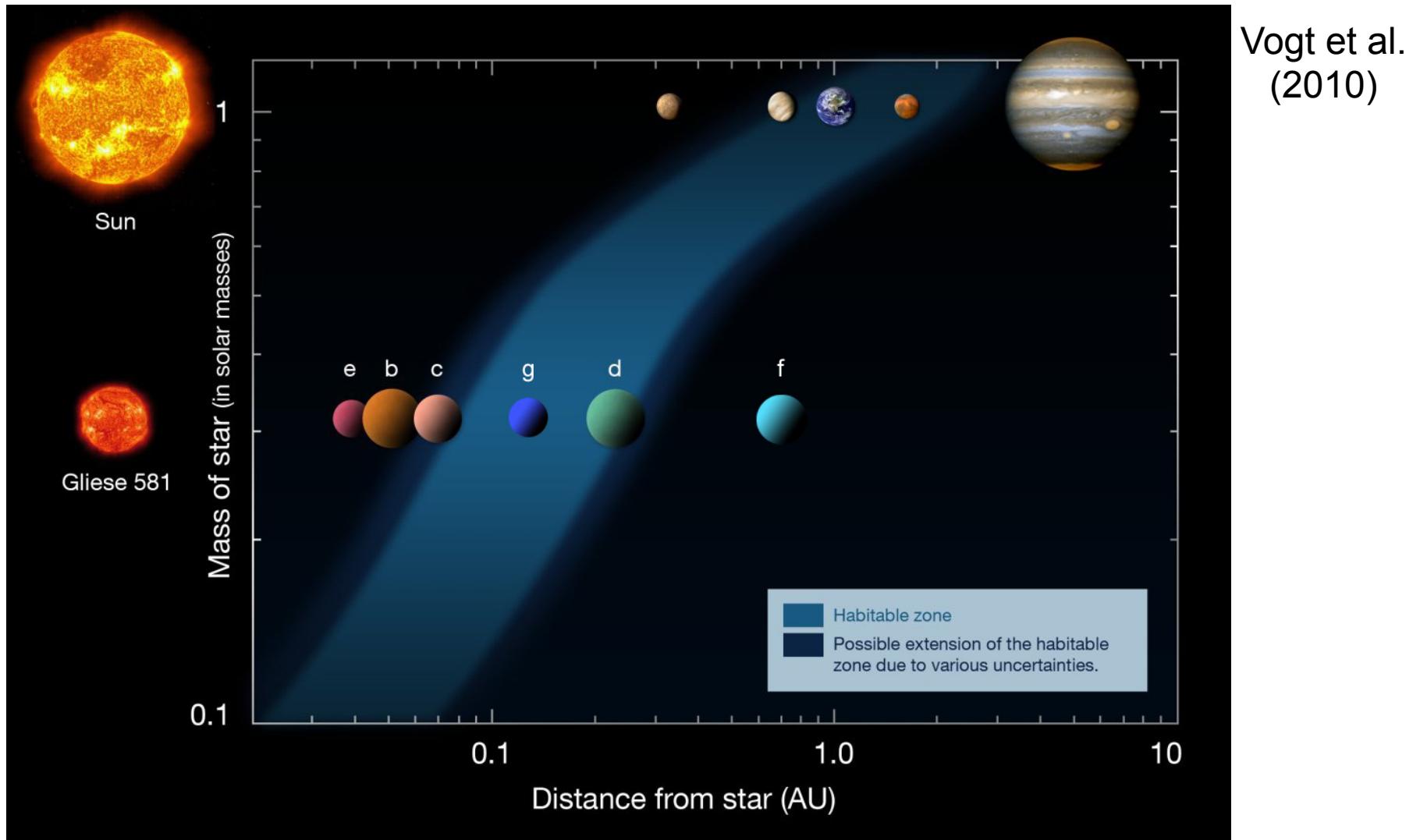
GJ 581 – Background



Mayor et al. (2009)

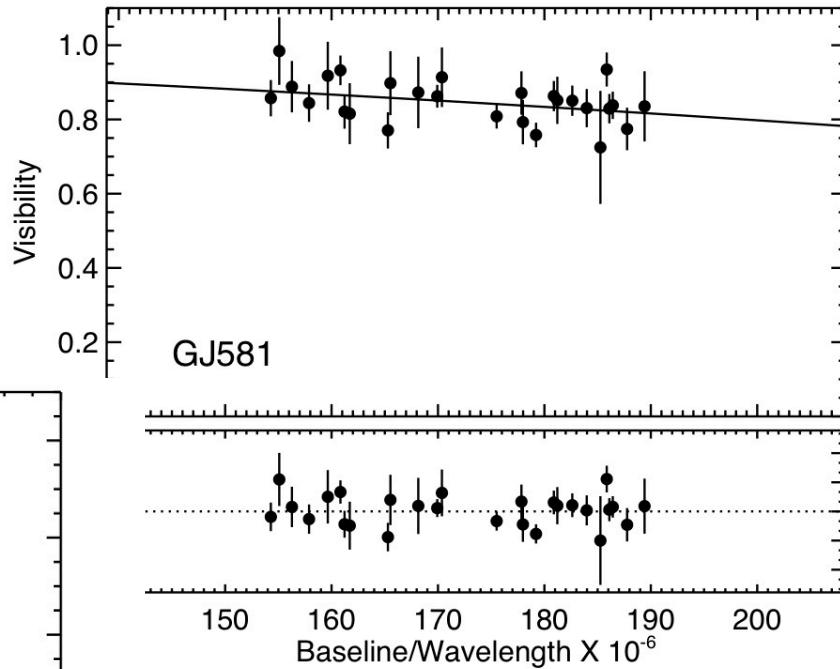
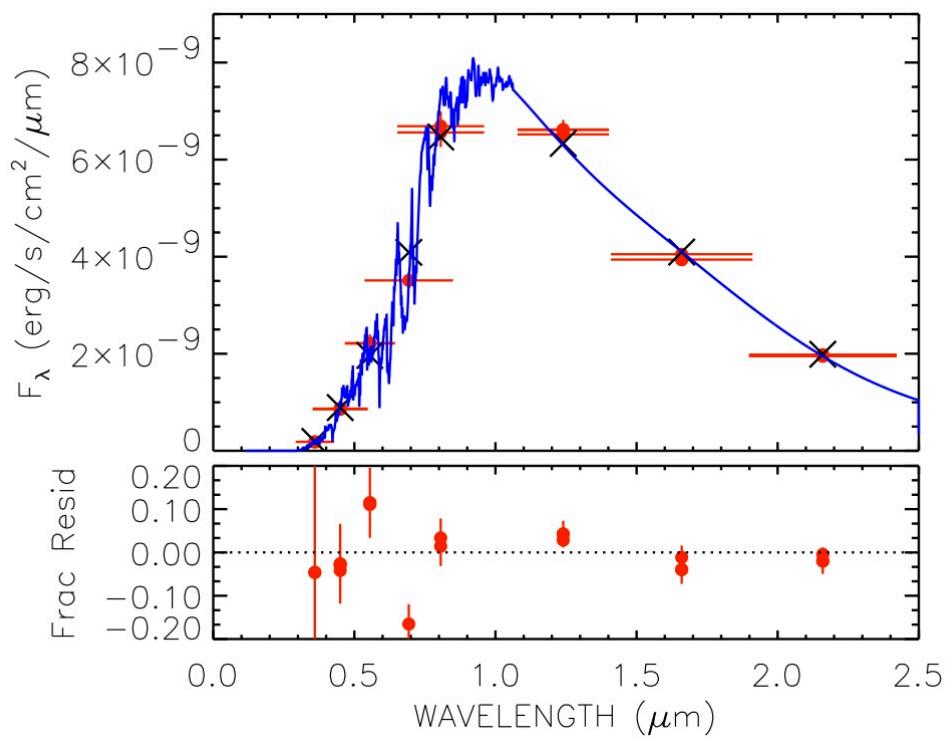


GJ 581 – Background





GJ 581 – Data



von Braun et al. (2011)



GJ 581 – Results

Stellar Parameters

Parameter

Value (Uncertainty)

θ_{UD} (mas)

0.433(14)

θ_{LD} (mas)

0.446(14)

$F_{BOL}(10^{-8} \text{ erg/s/cm}^2)$

0.992(1)

Radius (solar)

0.299(10)

Luminosity (solar)

0.0121(2)

T_{EFF} (K)

3498(56)

HZ boundaries (AU)

0.11—0.21

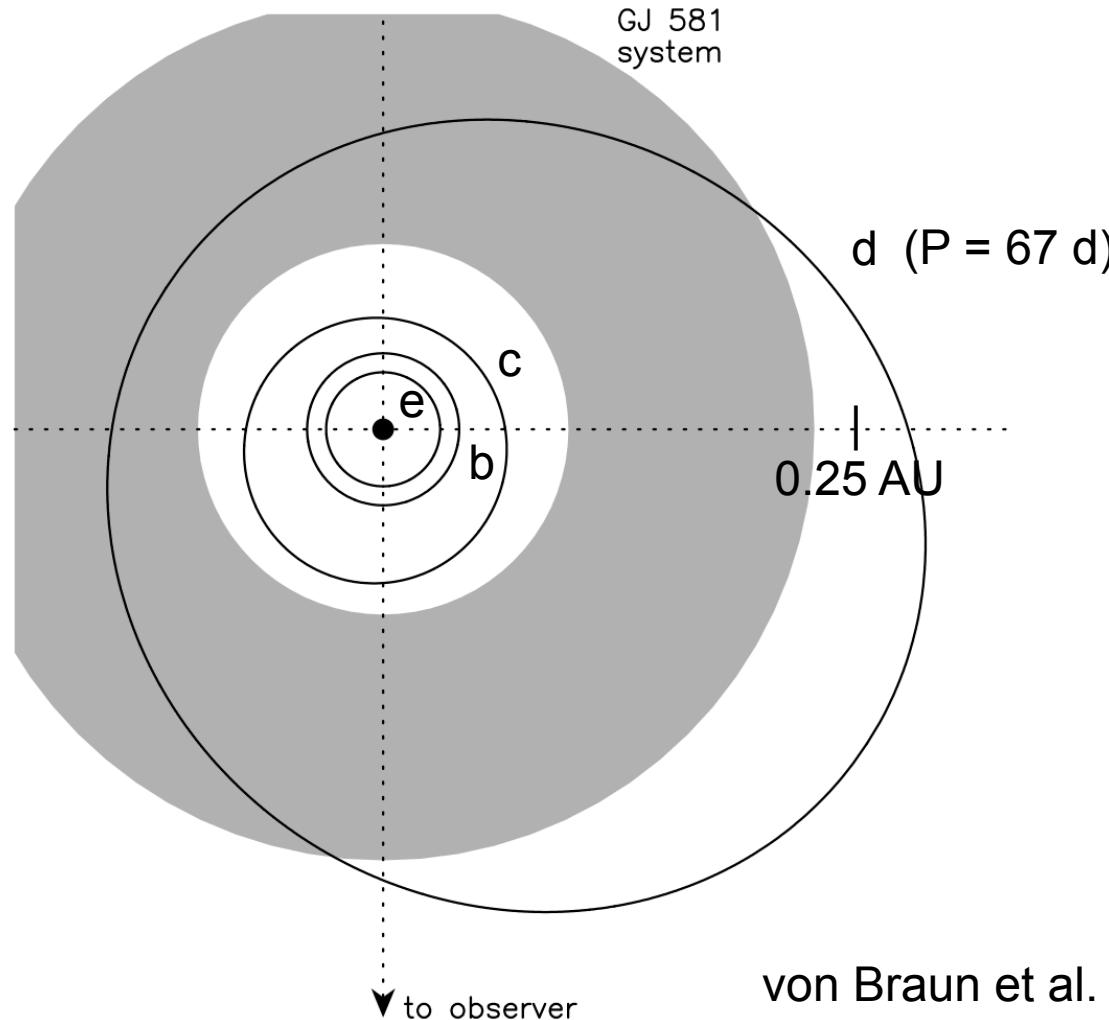
von Braun et al. (2011)





GJ 581 – Interpretation

Orbital parameters
(4 planets) from
Mayor et al. (2009)





GJ 581 – Interpretation

von Braun et al. (2011)

GJ 581
system

0.5 AU

(P = 433 d)

▼ to observer

GJ 581
system

(P = 67 d)

d

b

c

(P = 36.5 d)

▼ to observer



Habitable
Zone

Orbital parameters (6 planets) from Vogt et al. (2010)



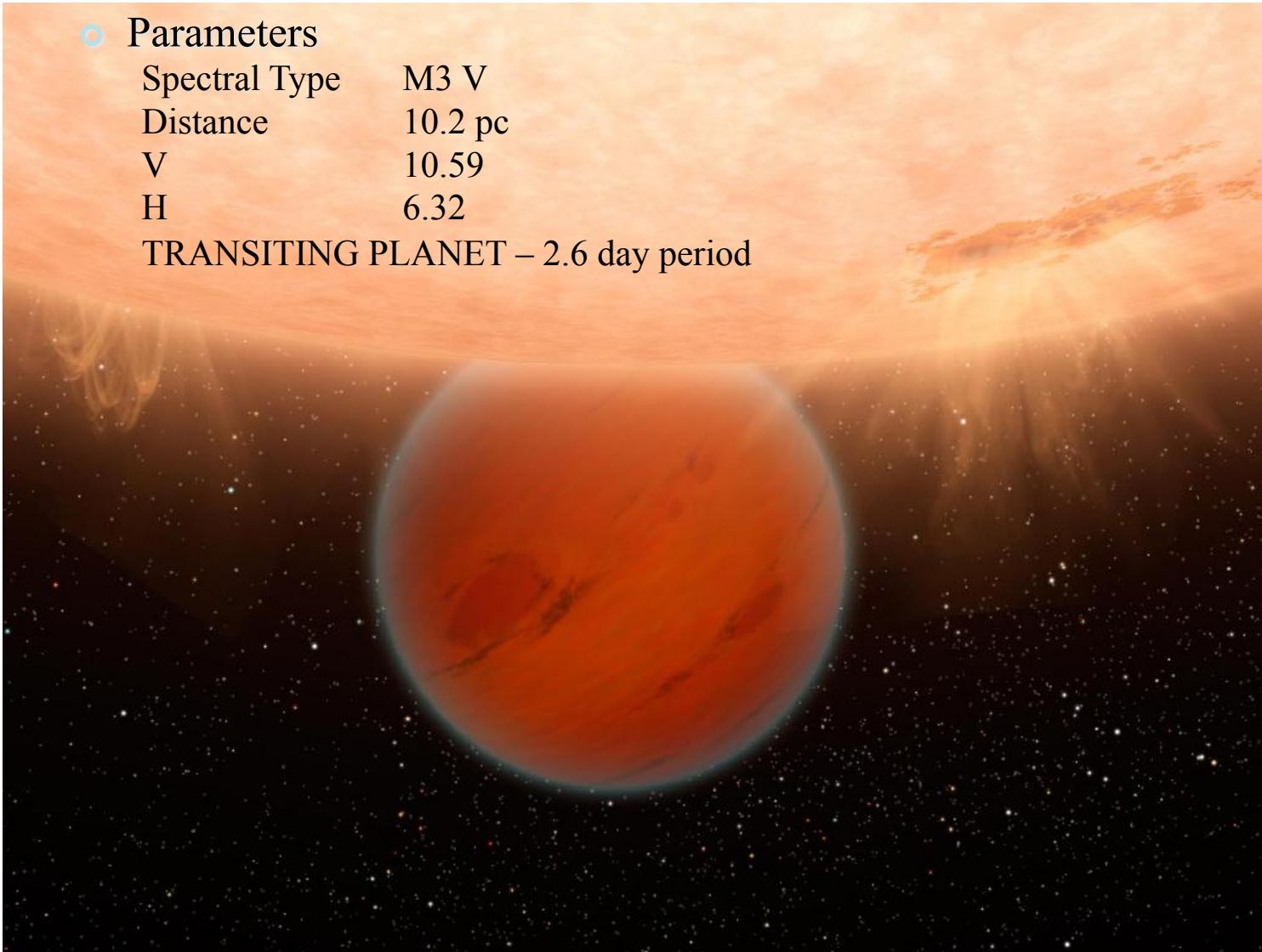


GJ 436 – Background

Parameters

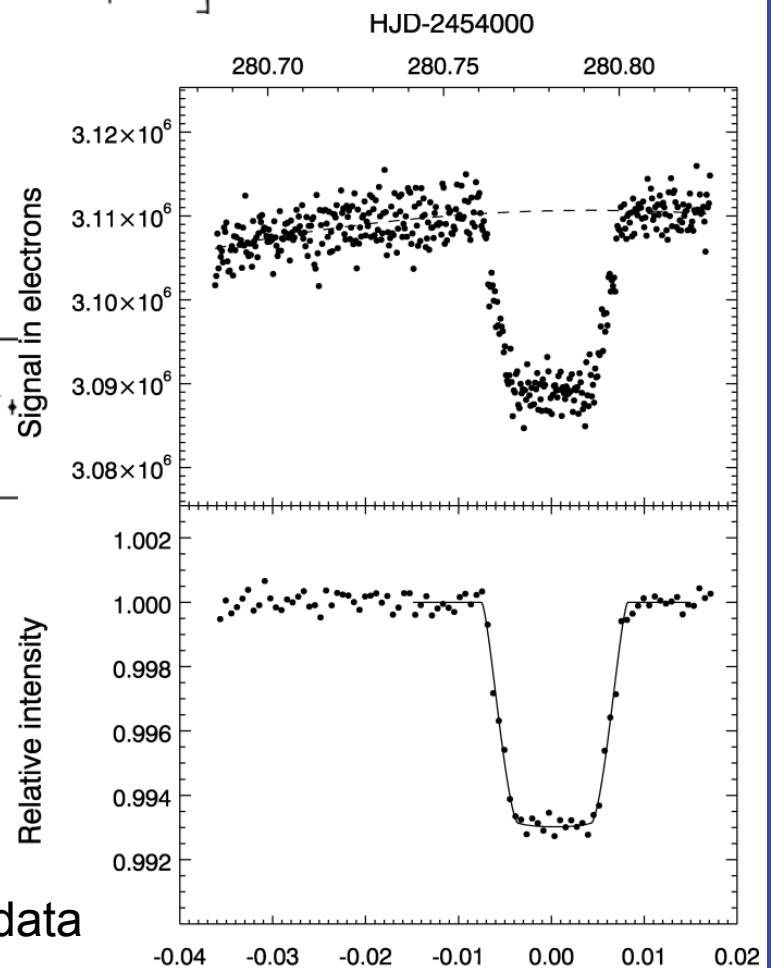
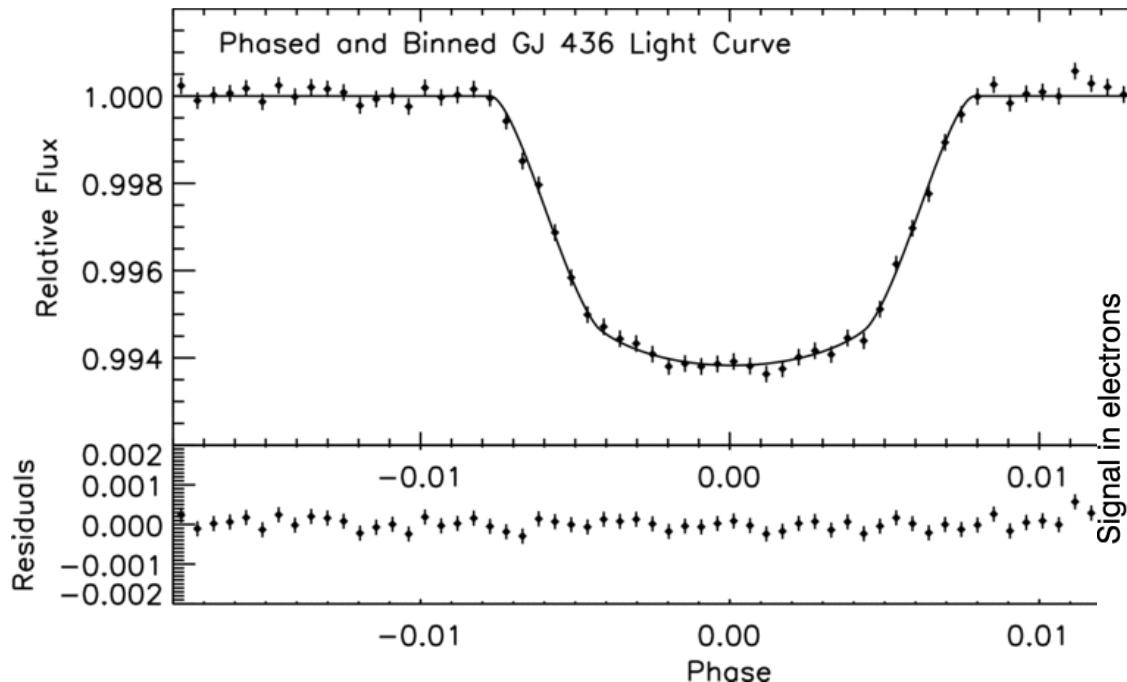
Spectral Type	M3 V
Distance	10.2 pc
V	10.59
H	6.32

TRANSITING PLANET – 2.6 day period





GJ 436 – Transits

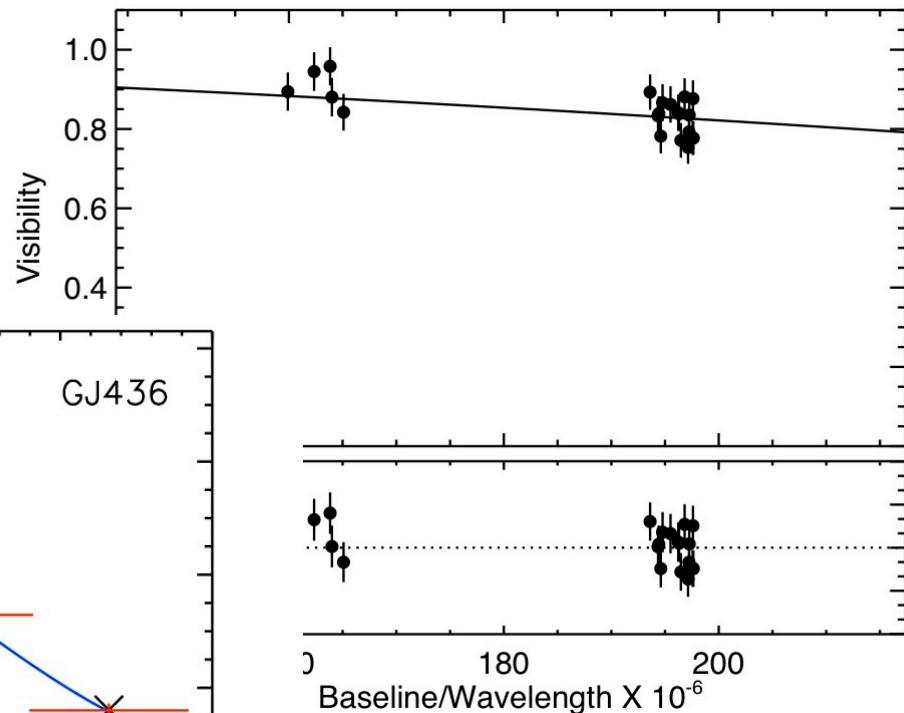
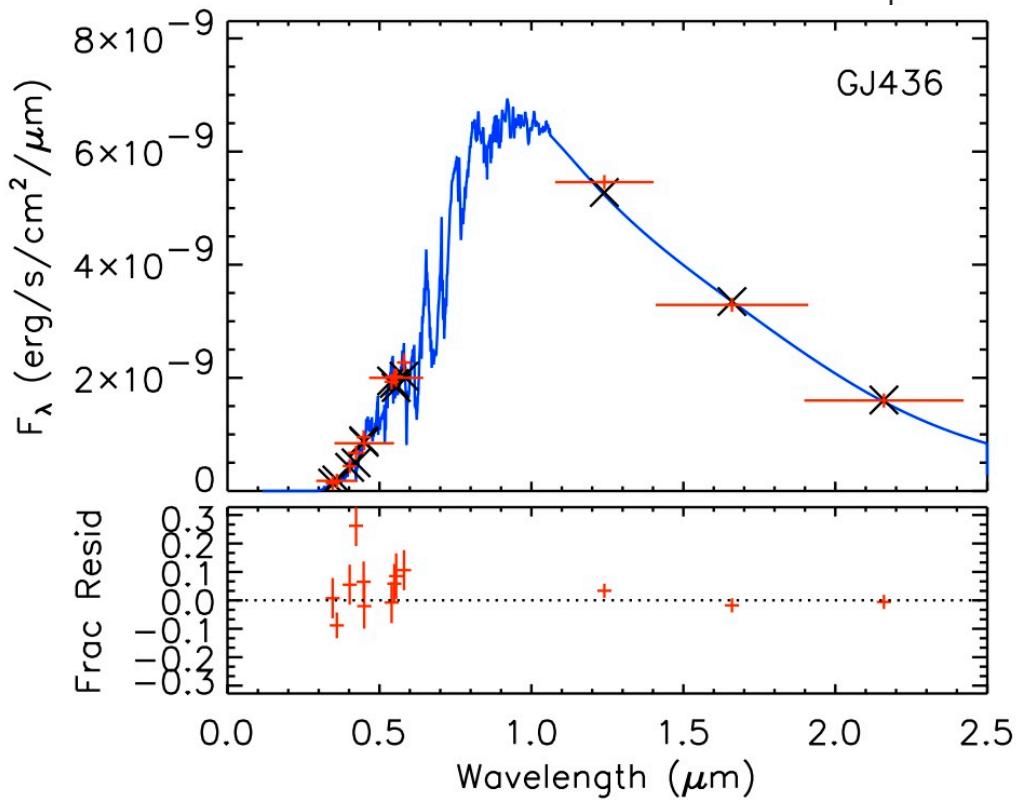


+ LESIA





GJ 436 – Data



von Braun et al. in prep



GJ 436 – The Star

○ Stellar Parameters

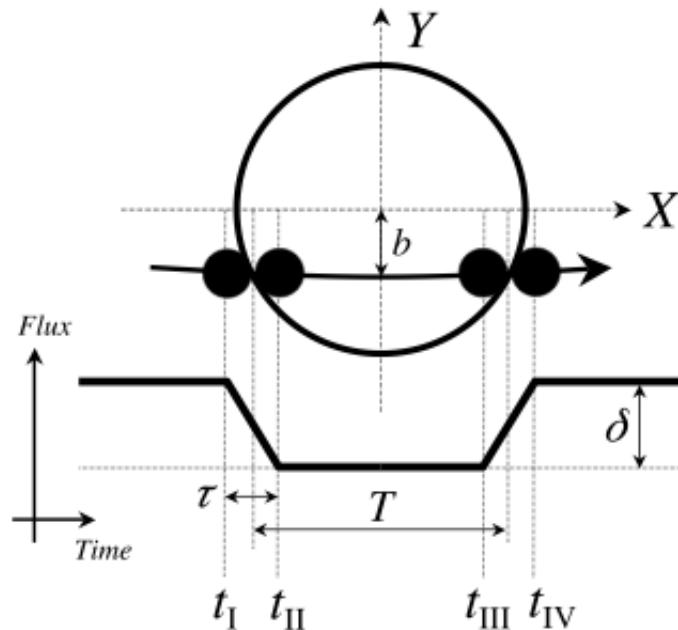
Parameter	Value (Uncertainty)
θ_{UD} (mas)	0.405(13)
θ_{LD} (mas)	0.414(13)
$F_{BOL}(10^{-8} \text{ erg/s/cm}^2)$	0.788(1)
Radius (solar)	0.452(18)
Luminosity (solar)	0.0257(1)
T_{EFF} (K)	3427(54)

von Braun et al. in prep





GJ 436b – Da Planet



Winn (2010)

For dark planet and
non-grazing transit:

$$\delta = k = R_p^2 / R_*^2$$

1. Deming et al. (2007), Stevenson et al. (2010): planet brightness temperature $\sim 700\text{-}1000\text{ K}$ (mid-IR).
2. Deming et al. (2007), Gillon et al. (2007a,b), Bean et al. (2008), Ballard et al. (2010), Pont et al. (2008), Shporer et al. (2009): non-grazing planet; measure δ ($\sim 0.006\text{-}0.007$).
3. Using our R_* and median literature δ , obtain:

$$R(GJ 436b) = (4.09 \pm 0.19) R_{\text{earth}}$$

More details...





GJ 614 & GJ 649

Stellar Parameters

Parameter

Spectral Type

GJ 614

K0 IV-V

θ_{UD} (mas)

GJ 649

M1

θ_{LD} (mas)

0.448(18)

0.472(12)

$F_{BOL}(10^{-8} \text{ erg/s/cm}^2)$

0.458(18)

0.484(12)

Radius (solar)

7.159(34)

1.279(9)

Luminosity (solar)

0.865(35)

0.539(16)

T_{EFF} (K)

0.6886(88)

0.0426(13)

HZ boundaries (AU)

5658(111)

3578(45)

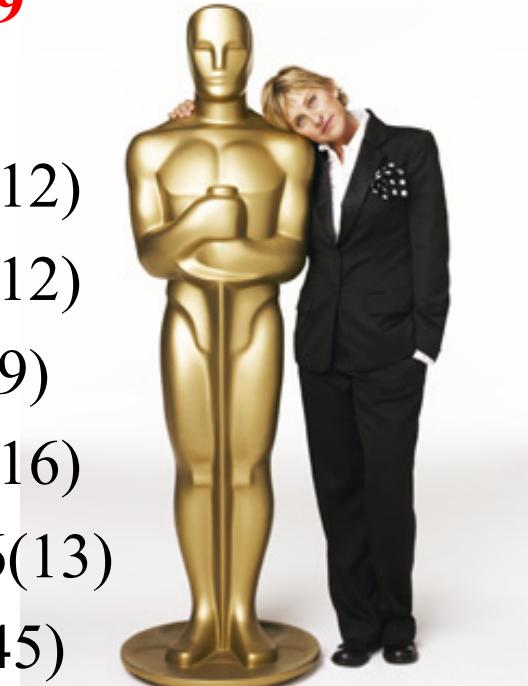
a_{Planet} (AU)

0.69—1.39

0.20—0.40

2.77

1.13



von Braun et al. in prep





COMING SOON





GJ 876 – The Future



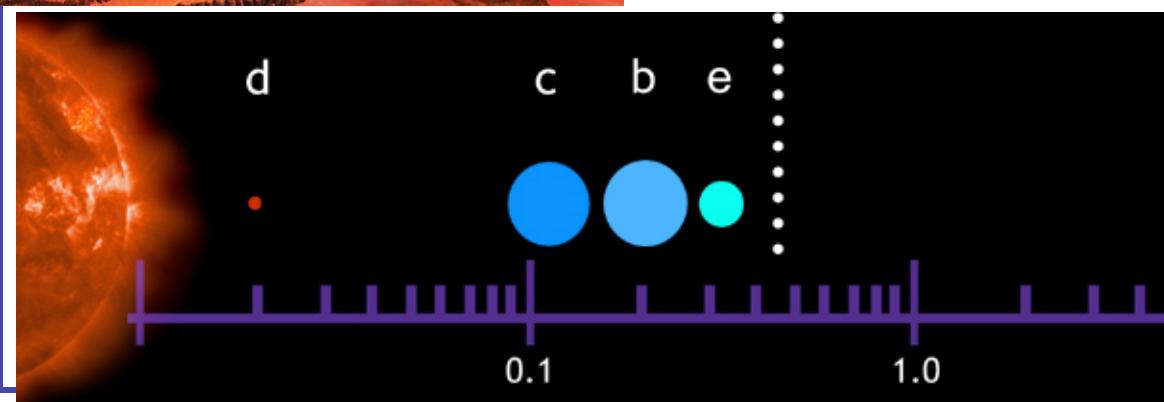
Spectral Type M3.5 V

Distance 4.7 pc

V 10.26

H 5.01

4 known planets
b & c potentially in HZ
HZ boundaries from
0.12—0.23 AU





Summary – “Understand the Parent Stars!”

- Directly determined astrophysical parameters:
 - Stellar radii & effective temperatures of late type, exoplanet hosting stars
 - Stellar luminosity and HZ
 - Planetary radius of GJ 436b
 - ✓ Provide direct characterization of exoplanets and their environments around late-type dwarfs.
- Current/future work
 - More late-type dwarfs observed and analyzed: GJ 176, HD 7924, HD 33564
 - Multiplanet exoplanet host GJ 876 (= very sexy)



Observatoire
de la CÔTE d'AZUR