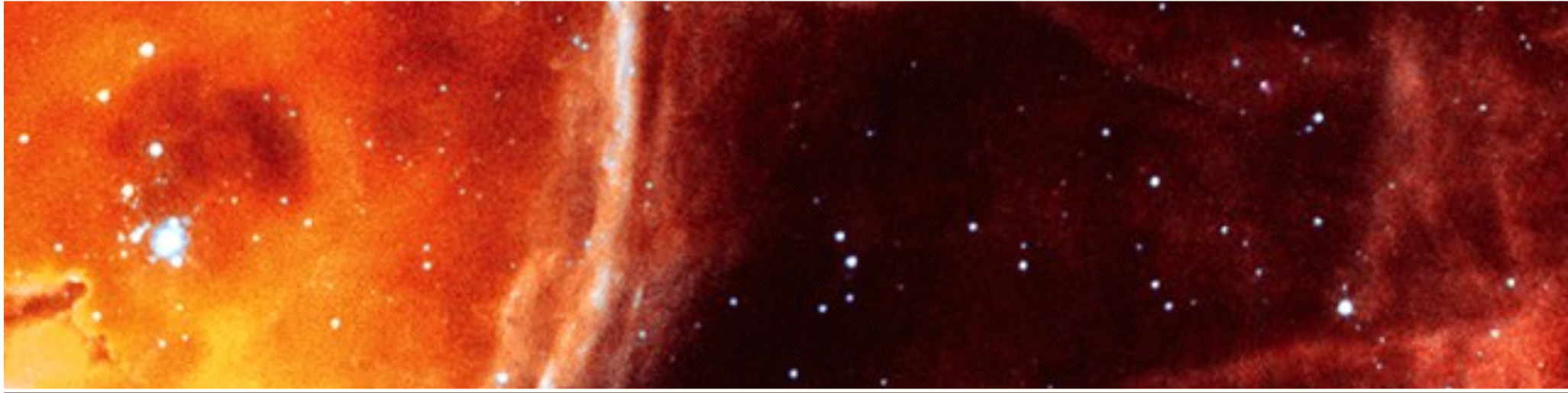


# *Discovering the Essential Universe*



Neil F. Comins

## CHAPTER 5 Exoplanets

# Exoplanets

(Extrasolar planets)

Beta Pictoris -- a circumstellar disk of matter

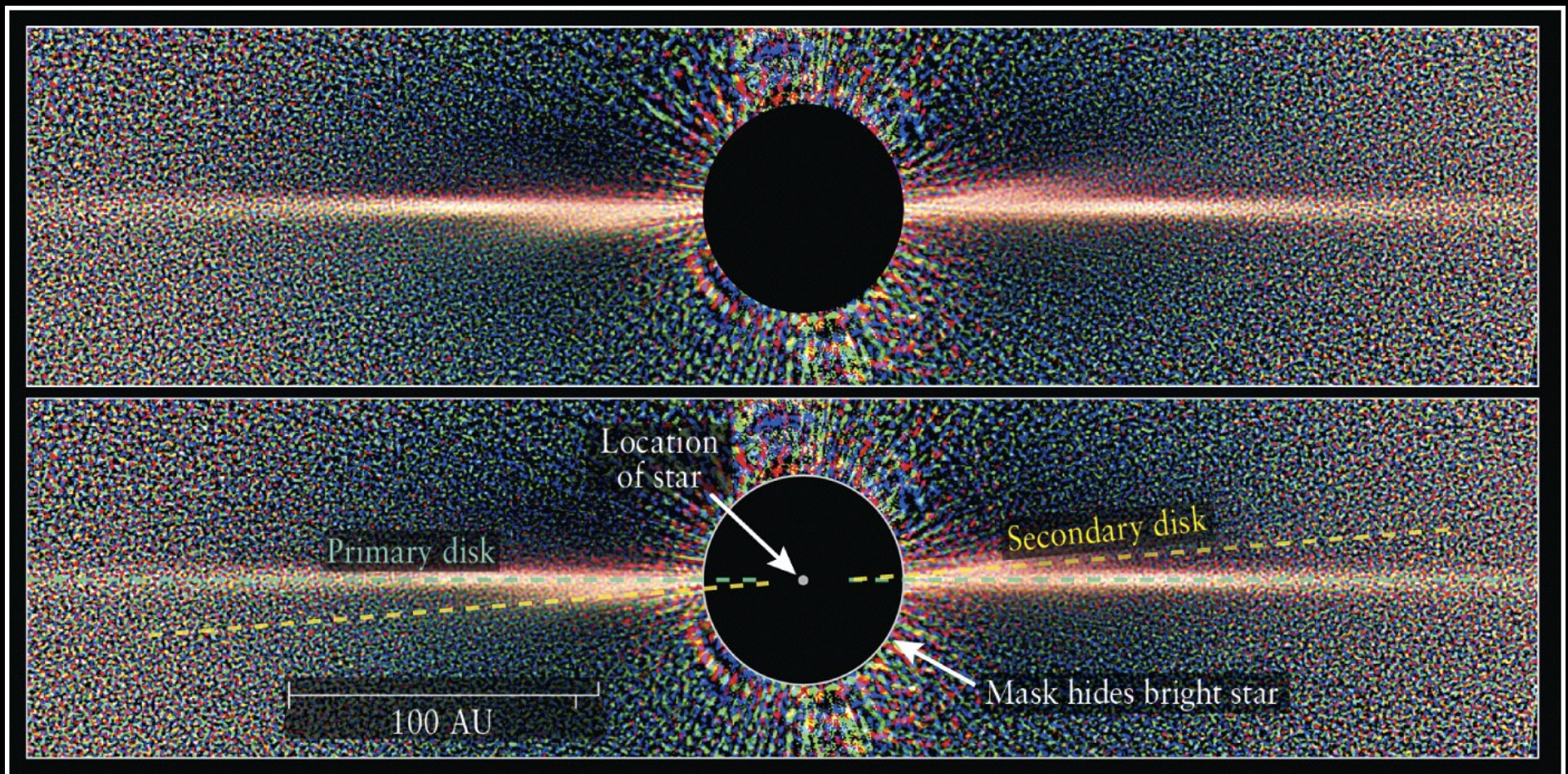
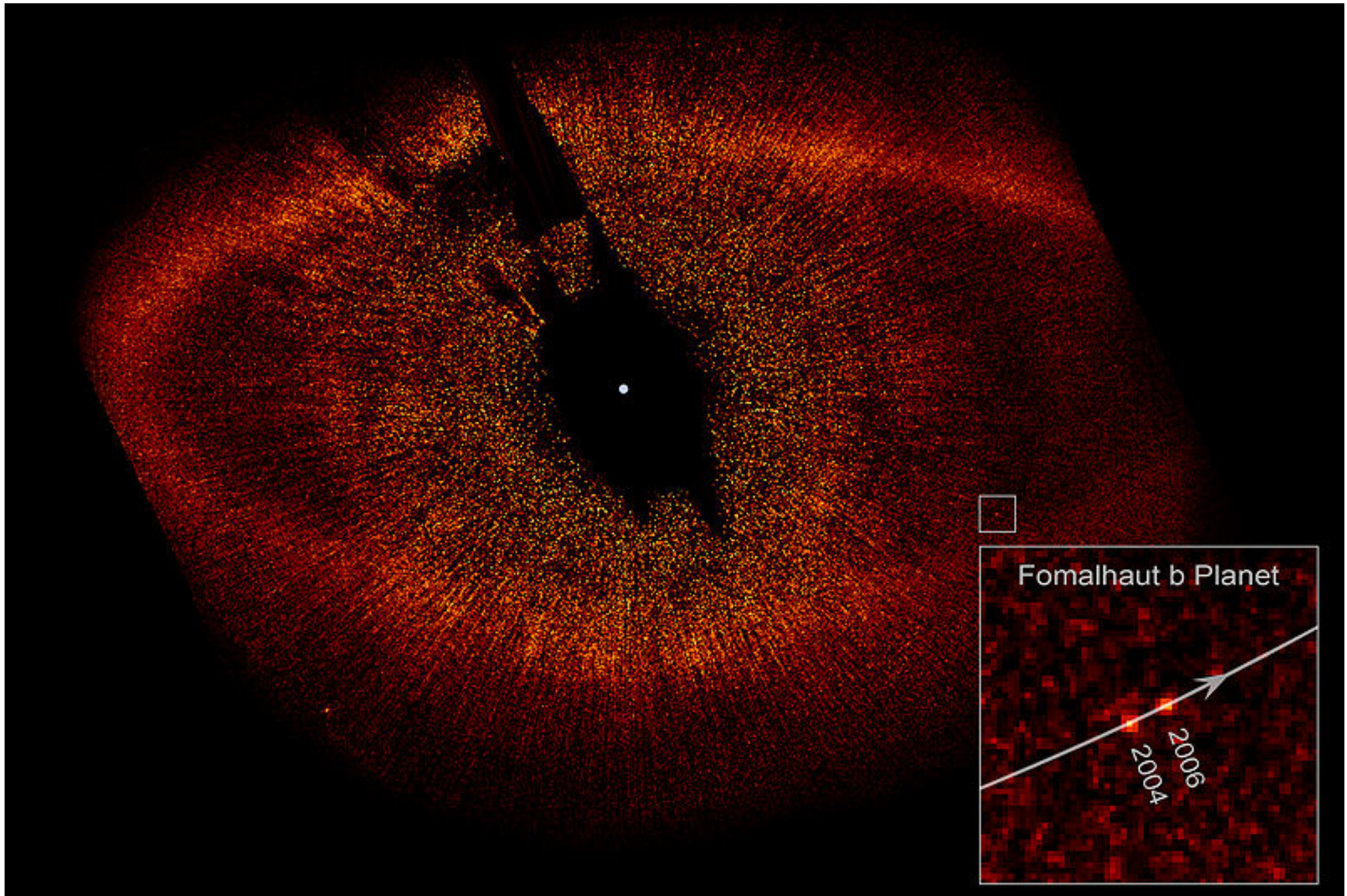


Figure 5-12de

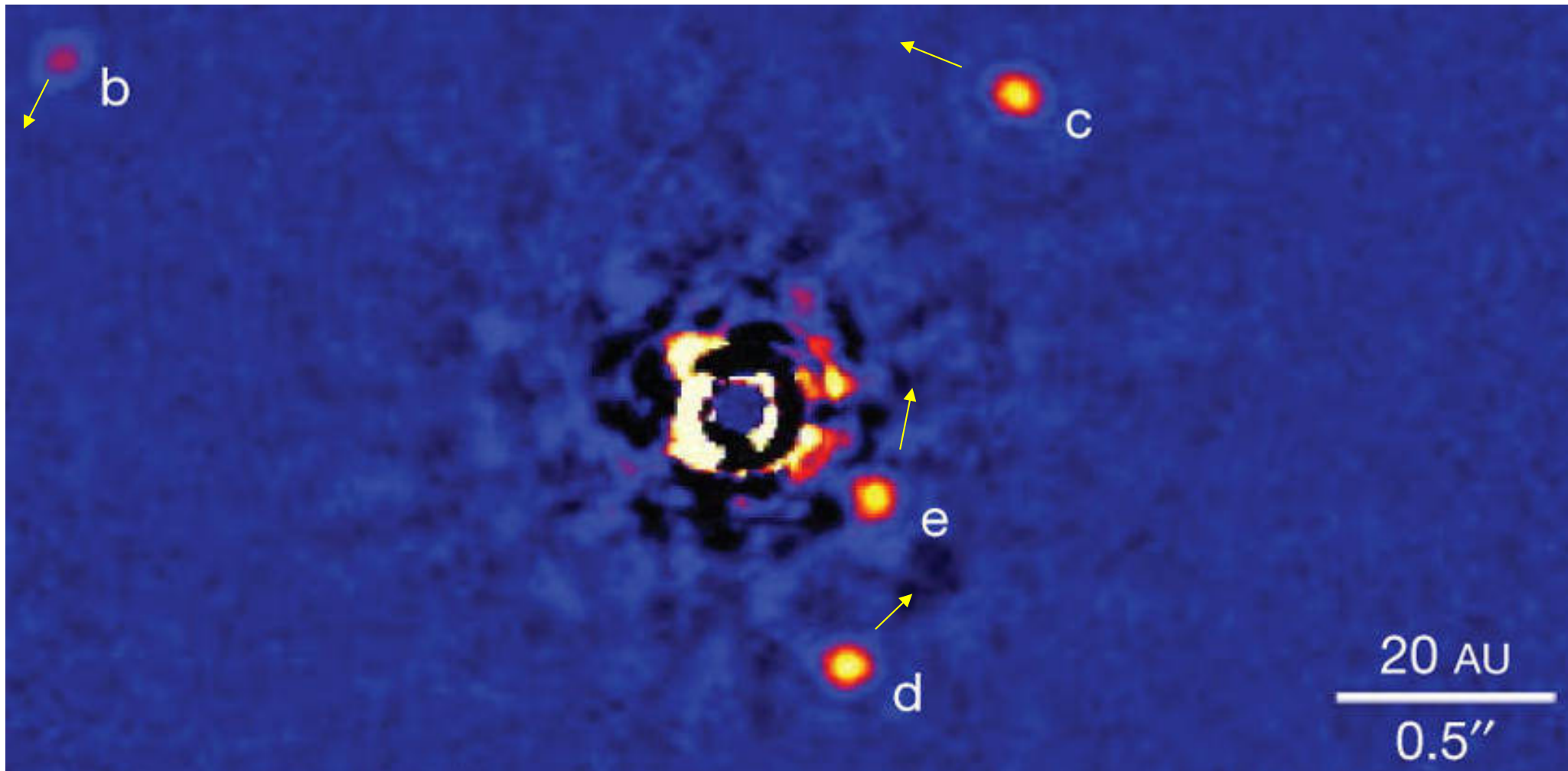
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NASA, ESA and P. Kalas UC Berkeley, SETI Inst.

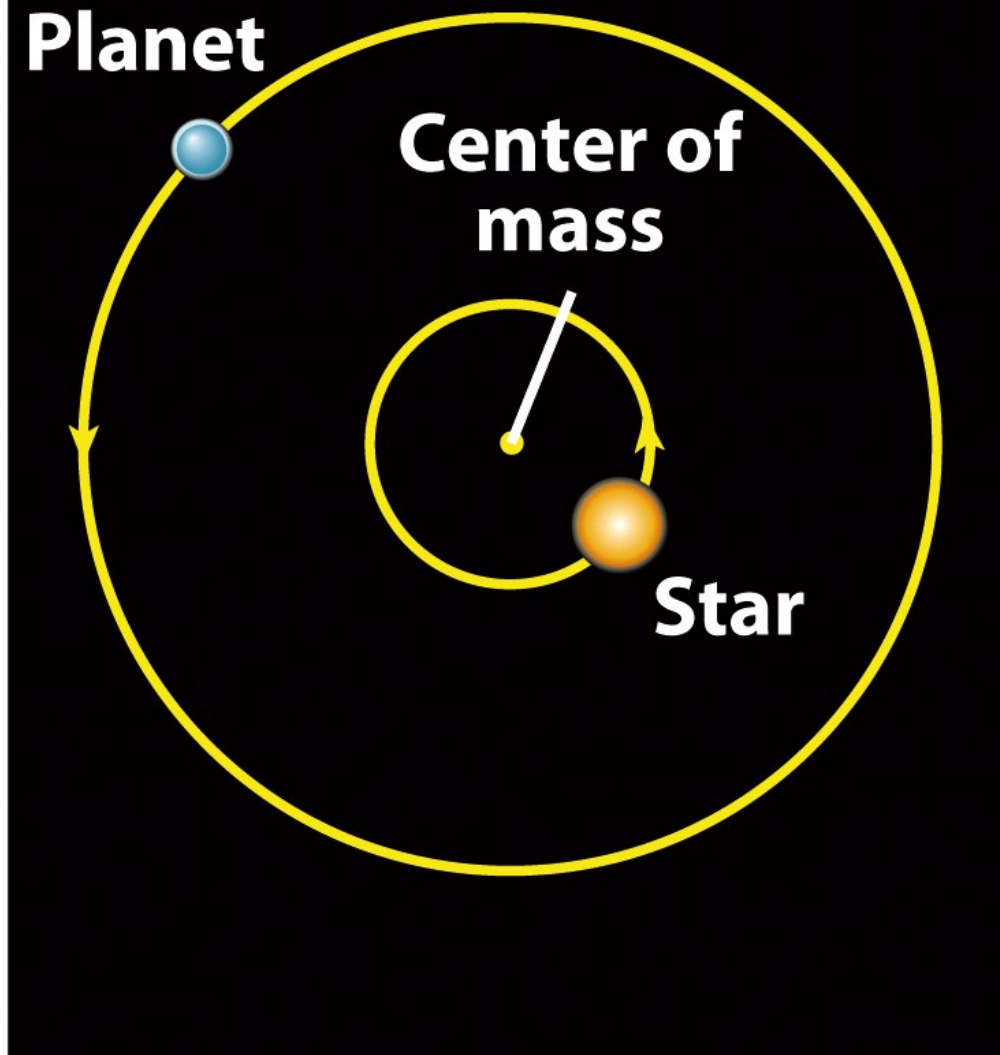
# HR8799



The first directly imaged multi-exoplanet system. This system contains a debris disk and at least four massive planets.

**Credits: NRC-HIA, Christian Marois, Keck Observatory**

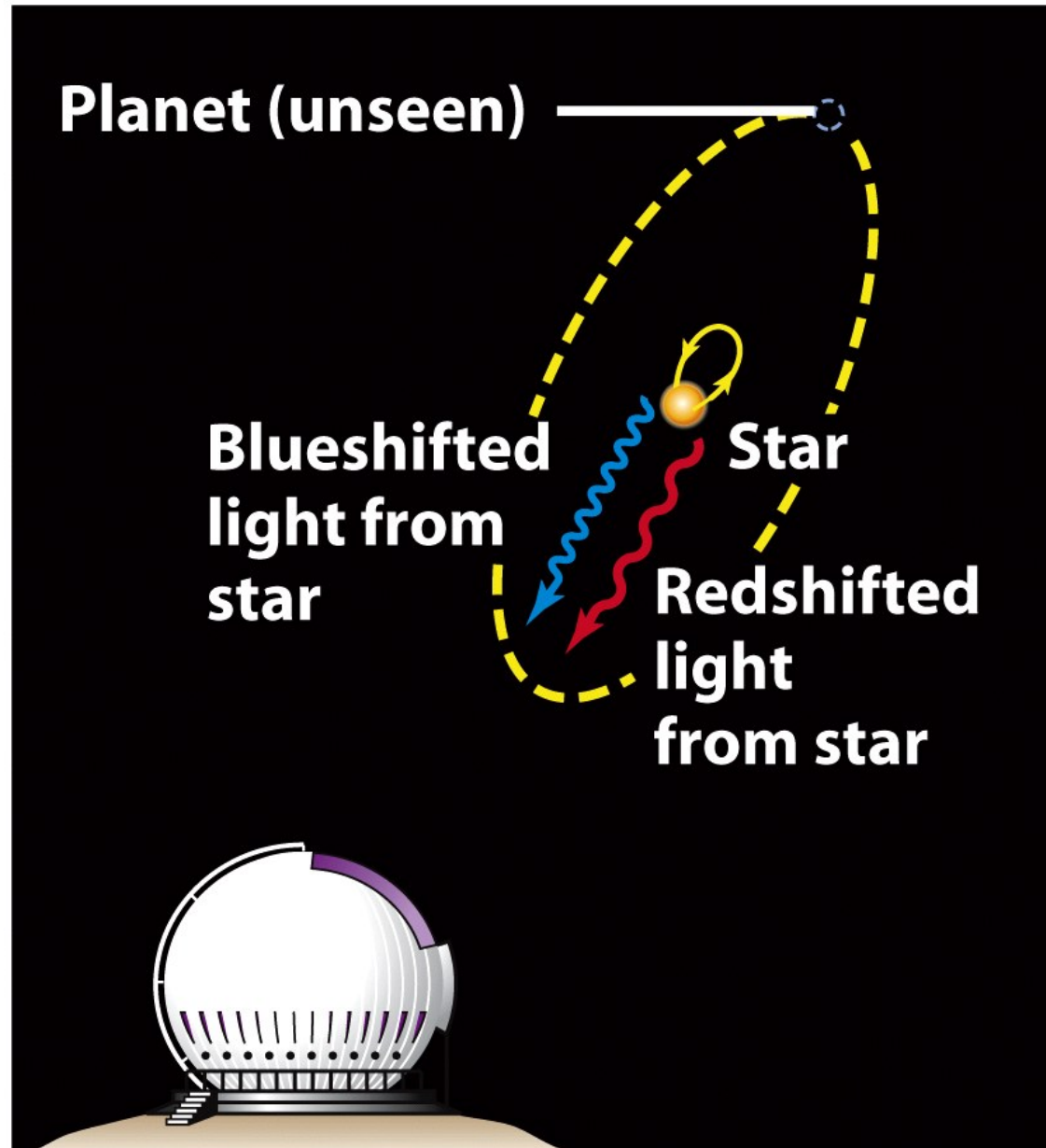
# How to detect exoplanets?



## A star and its planet

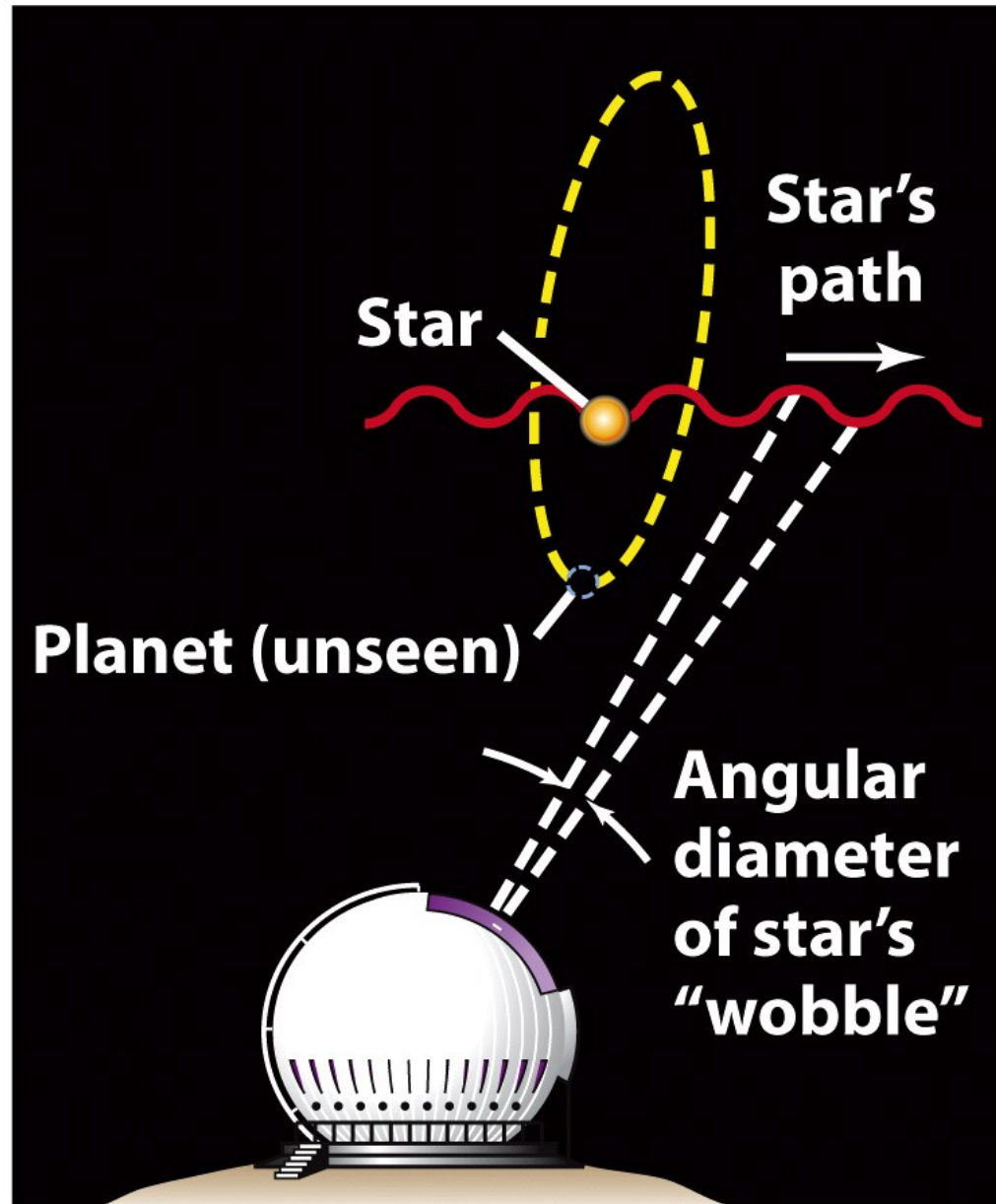
Figure 5-15a  
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The direct imaging method (very rare)



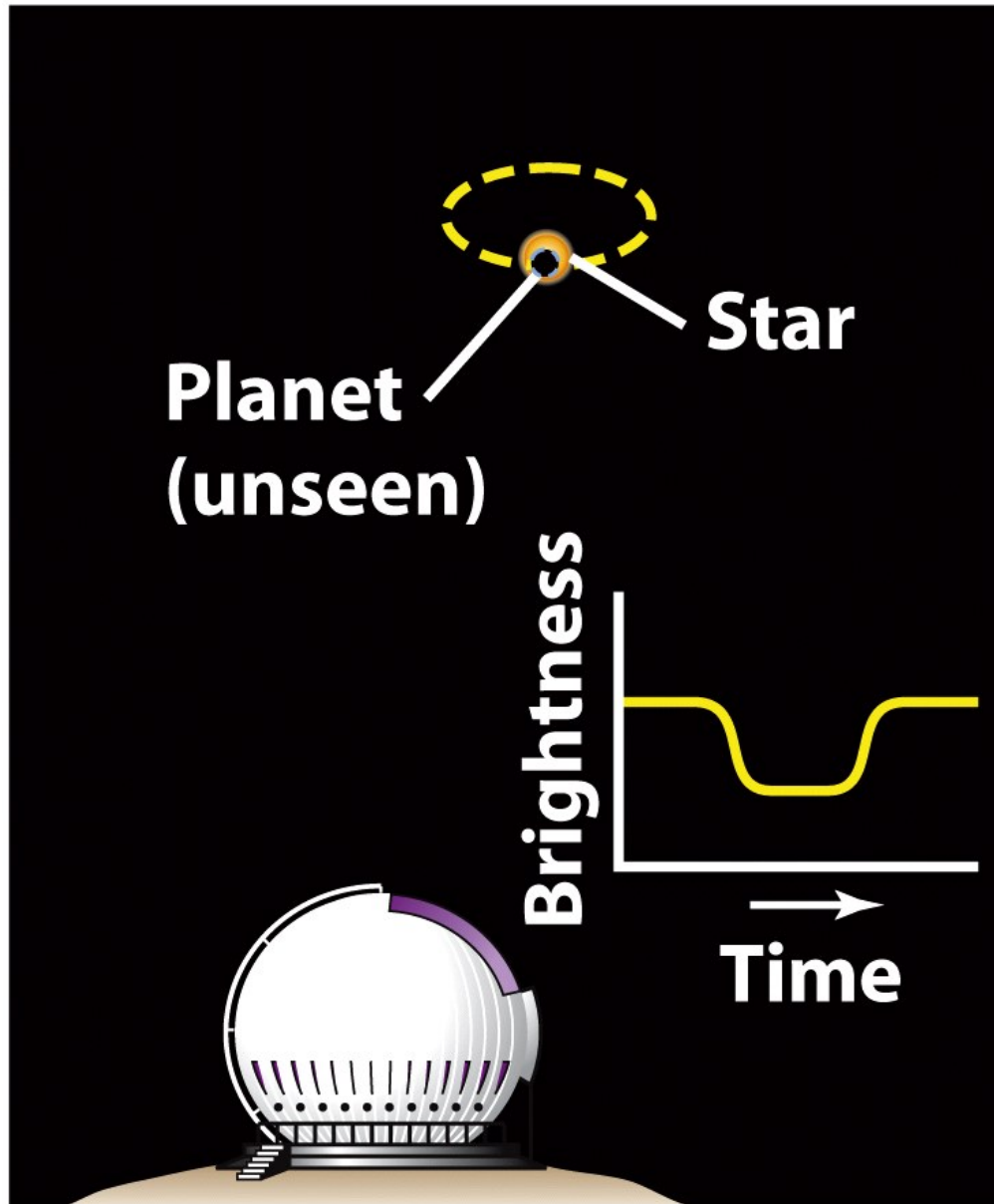
## The radial velocity method

Figure 5-15b  
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# The astrometric method

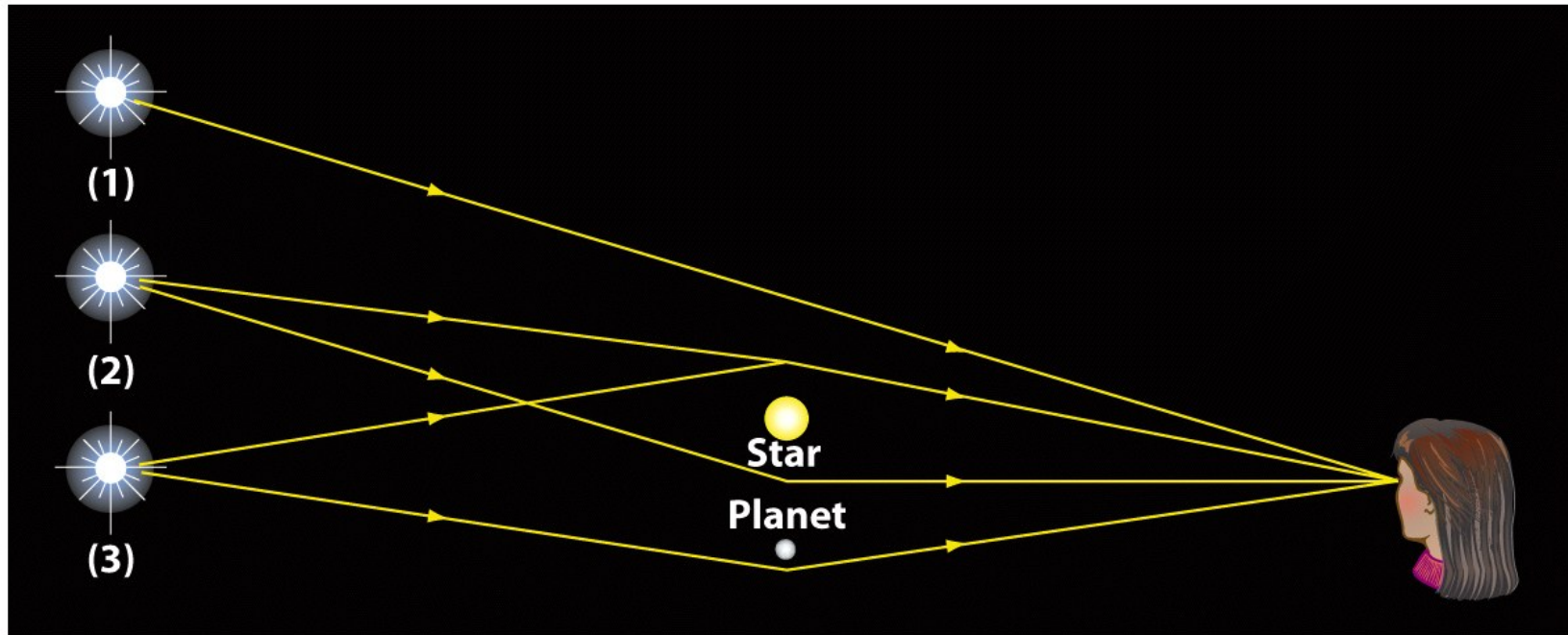
Figure 5-15c  
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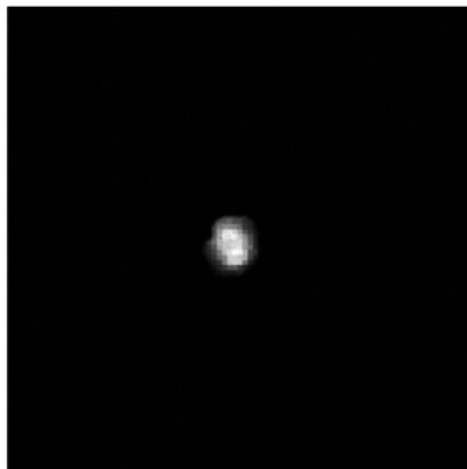
# The transit method

Figure 5-15d  
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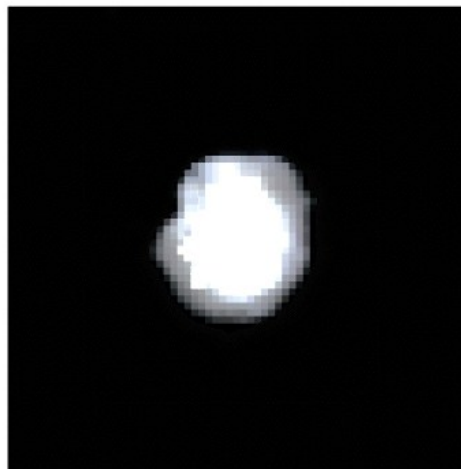




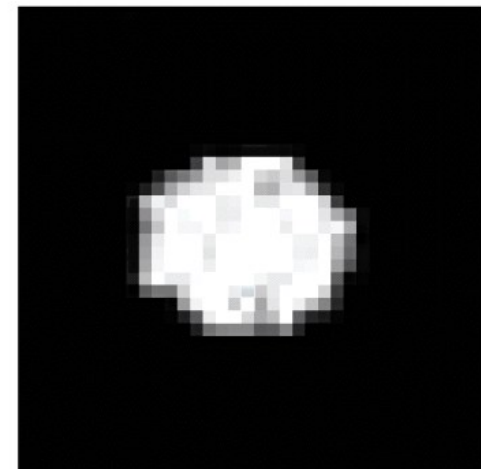
**a**



**(1) No microlensing**



**(2) Microlensing by star**



**(3) Microlensing by star and planet**

**b**

Figure 5-17  
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# The microlensing method

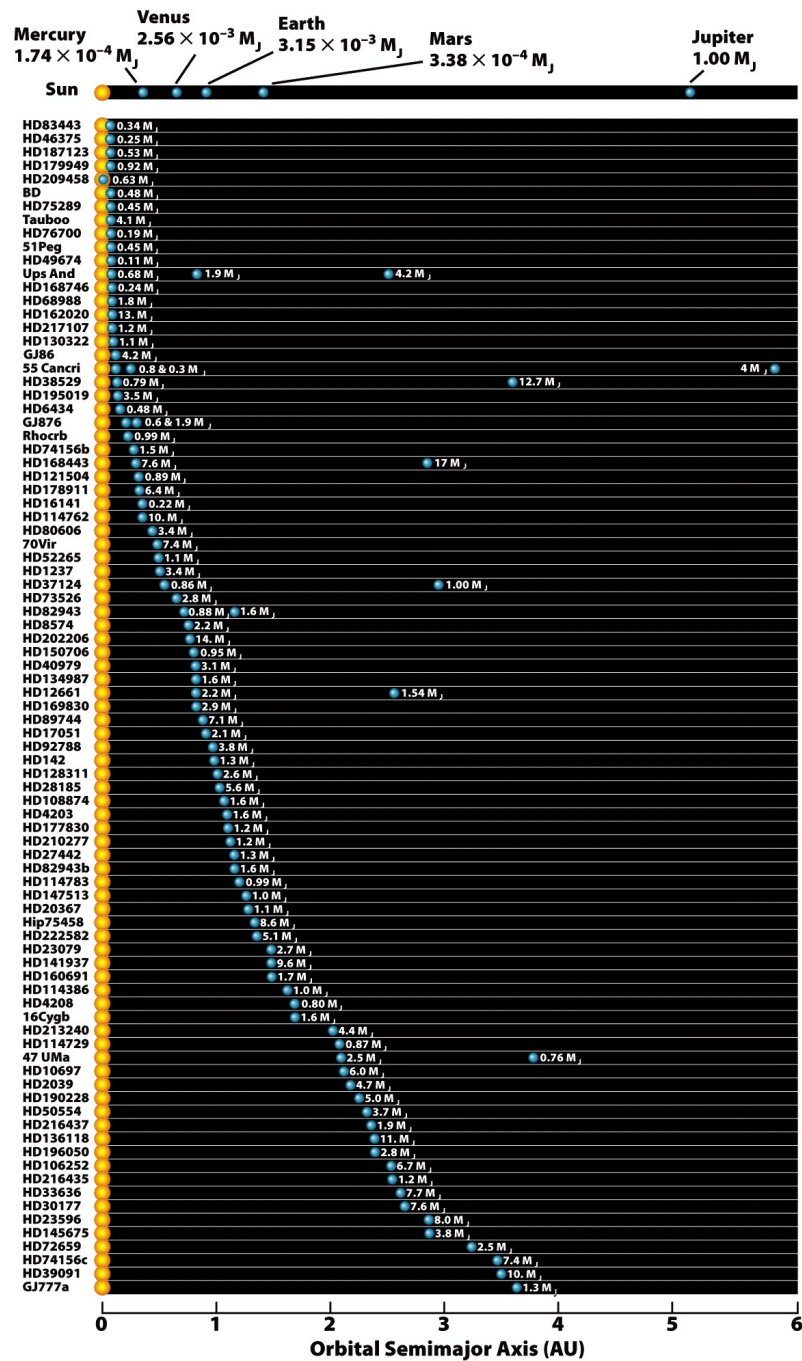
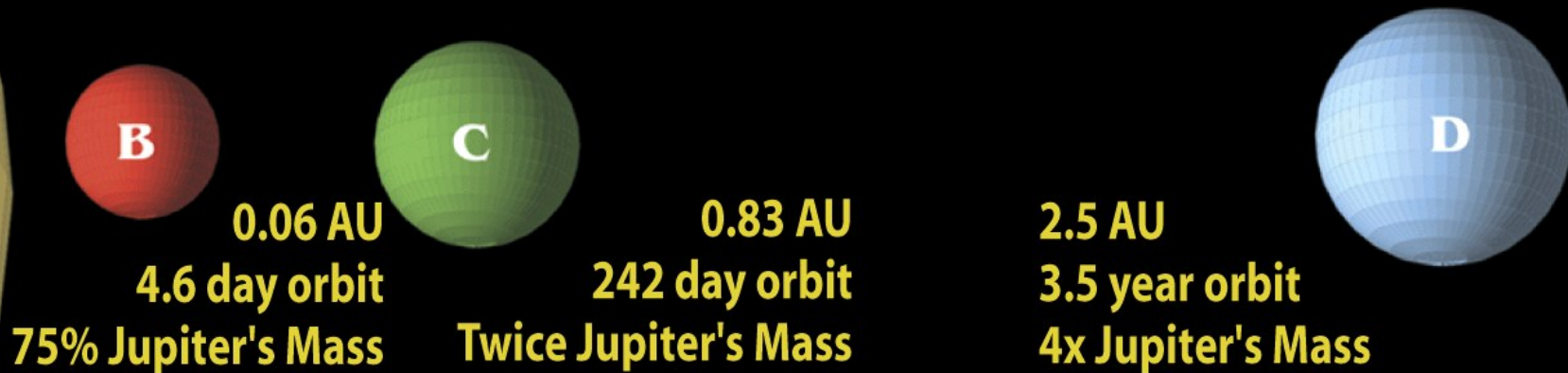


Figure 5-16  
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# The Upsilon Andromedea System



## Our Inner Solar System

Planet	Distance (AU)	Orbit Period
Mercury	0.39 AU	89 day orbit
Venus	0.73 AU	228 day orbit
Earth	1.00 AU	1 year orbit
Mars	1.54 AU	1.9 year orbit

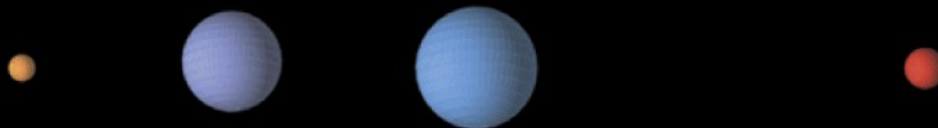
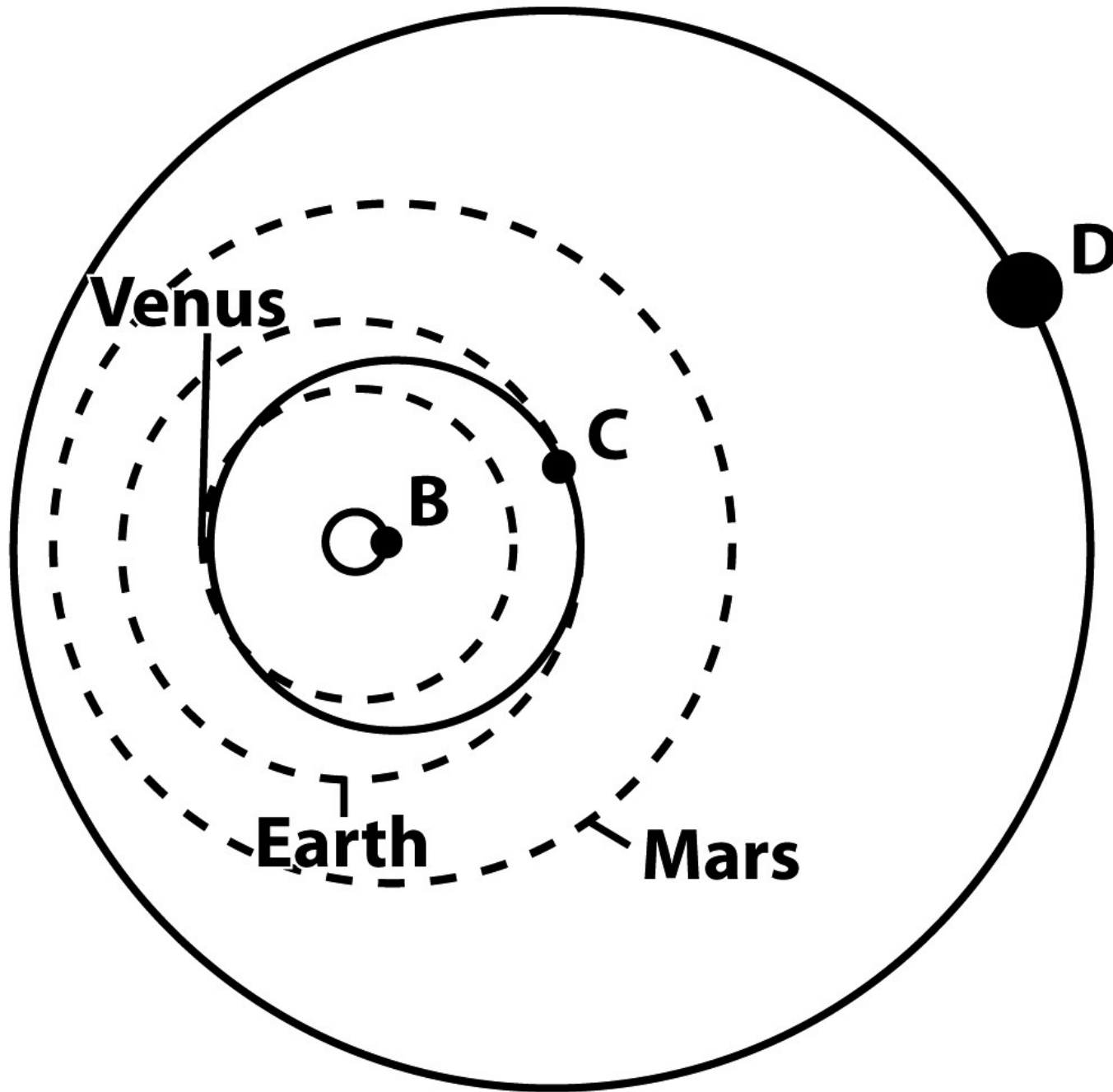


Figure 5-18a  
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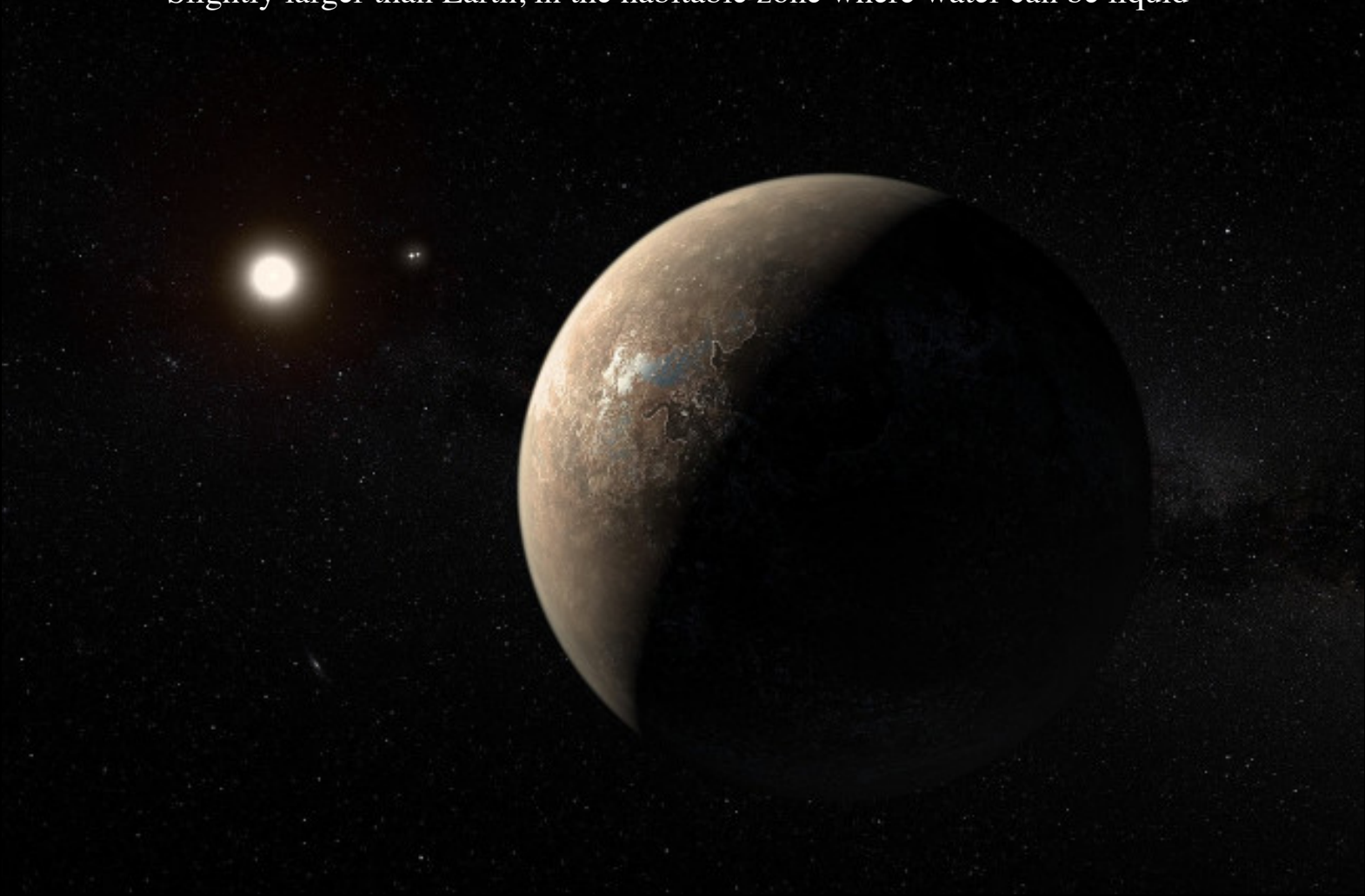


**Figure 5-18b**  
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# The closest exoplanet

Proxima Centauri b, 4.2 ly away

Slightly larger than Earth, in the habitable zone where water can be liquid

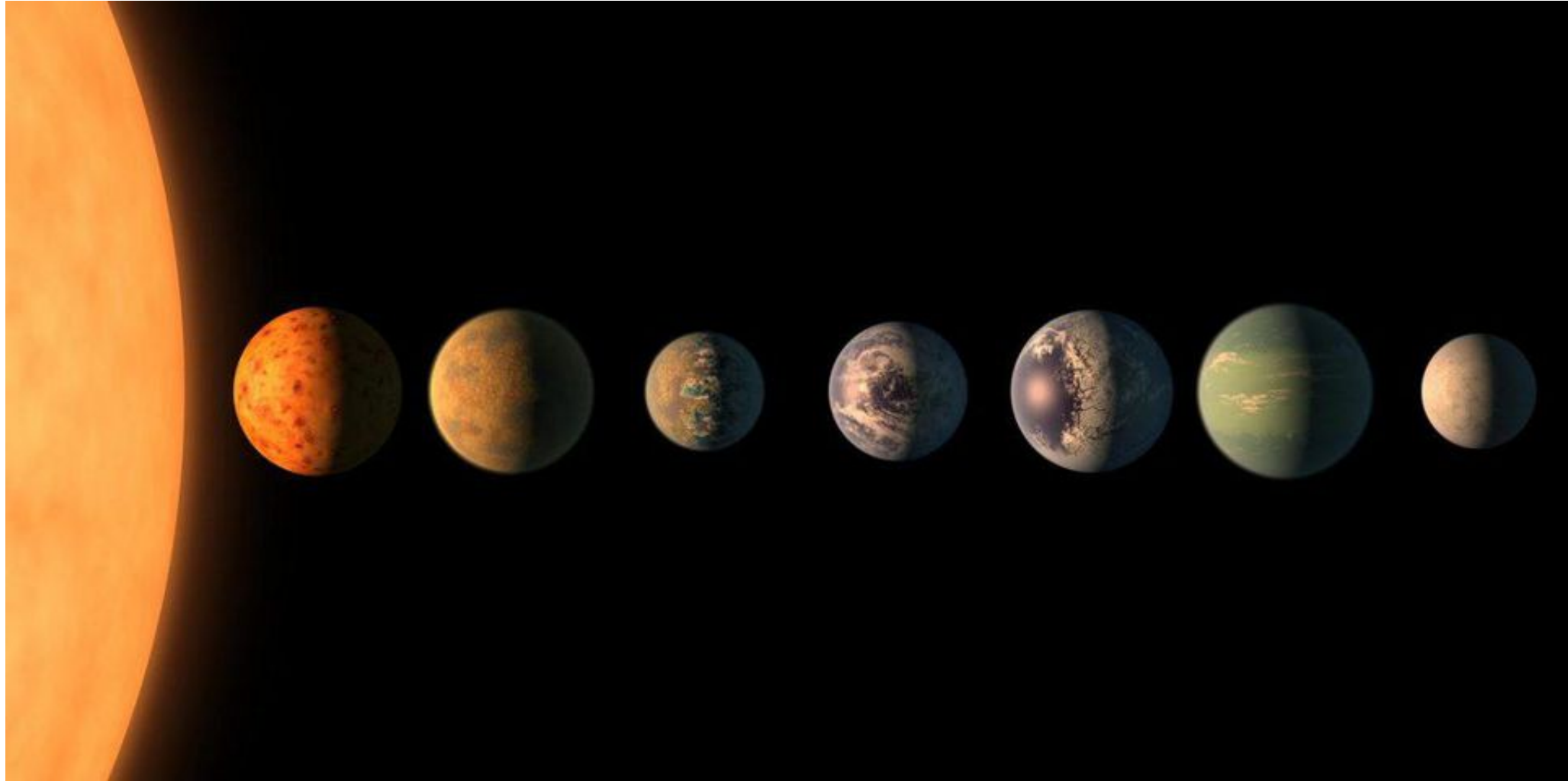


An artist's conception of Proxima Centauri b as a rocky-like exoplanet, with Proxima Centauri and the Alpha Centauri binary system in the background. The actual appearance of the planet is unknown.

<https://astronomy.com/news/2020/02/proxima-centauri-the-closest-exoplanet-to-earth>

ESO/M. Kornmesser

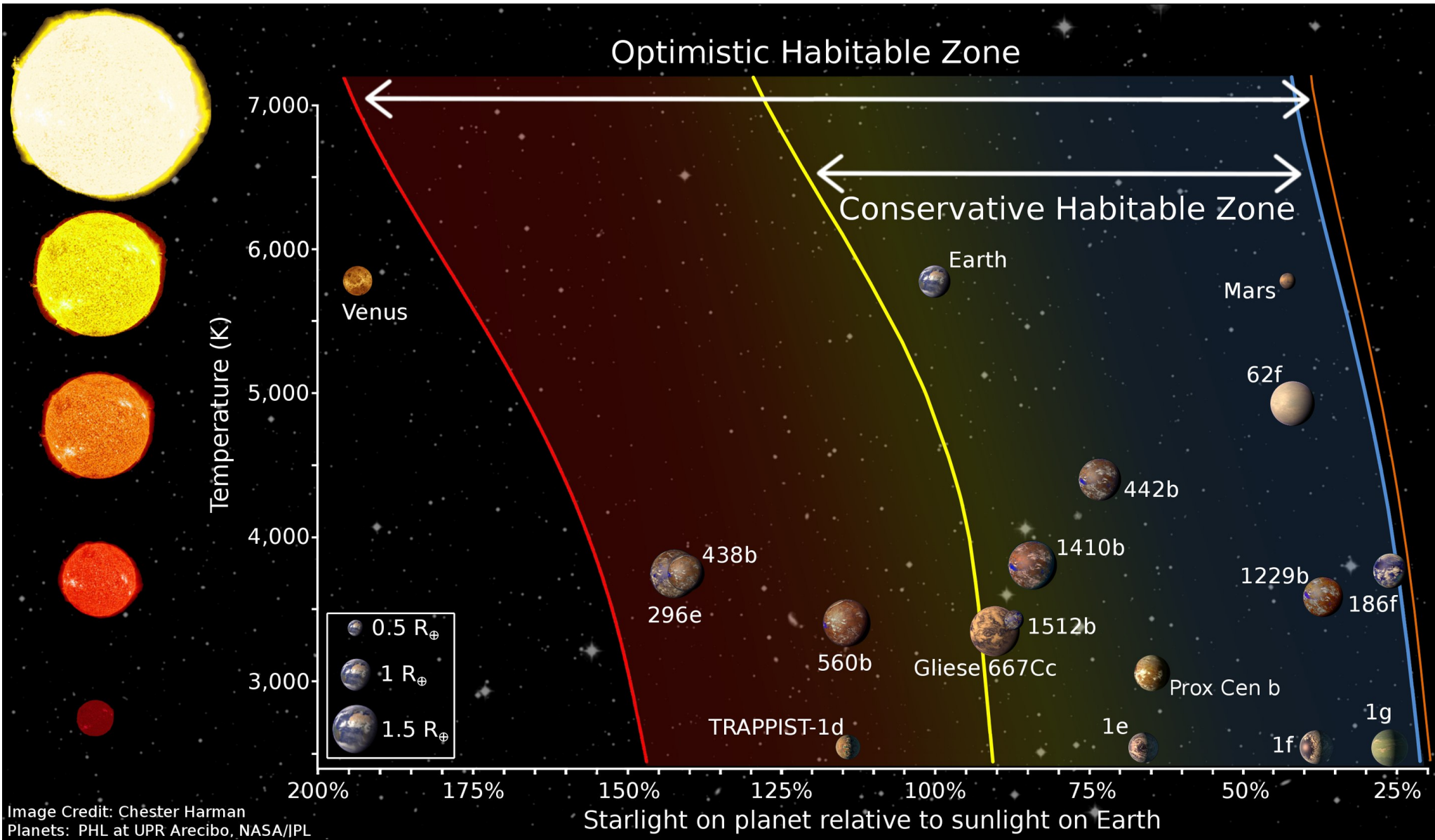
## The seven TRAPPIST-1 planets.



The seven TRAPPIST-1 planets.

CREDIT: NASA / JPL - CALTECH

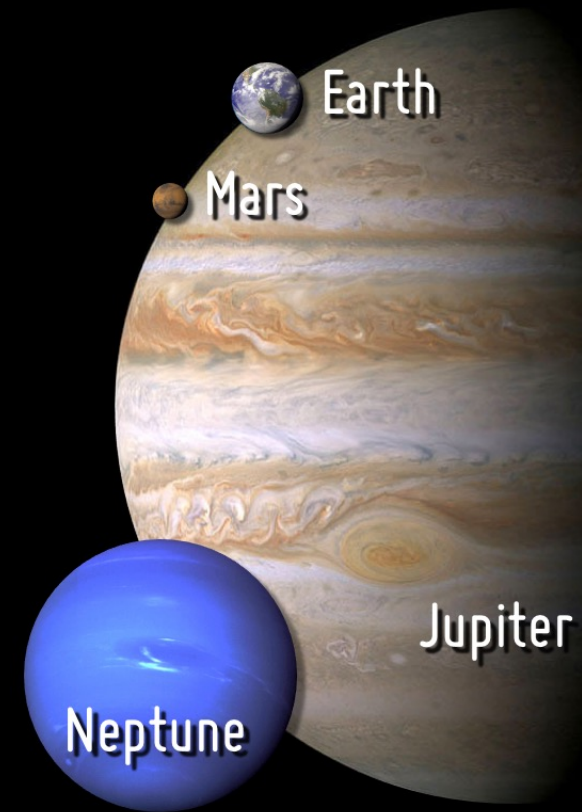
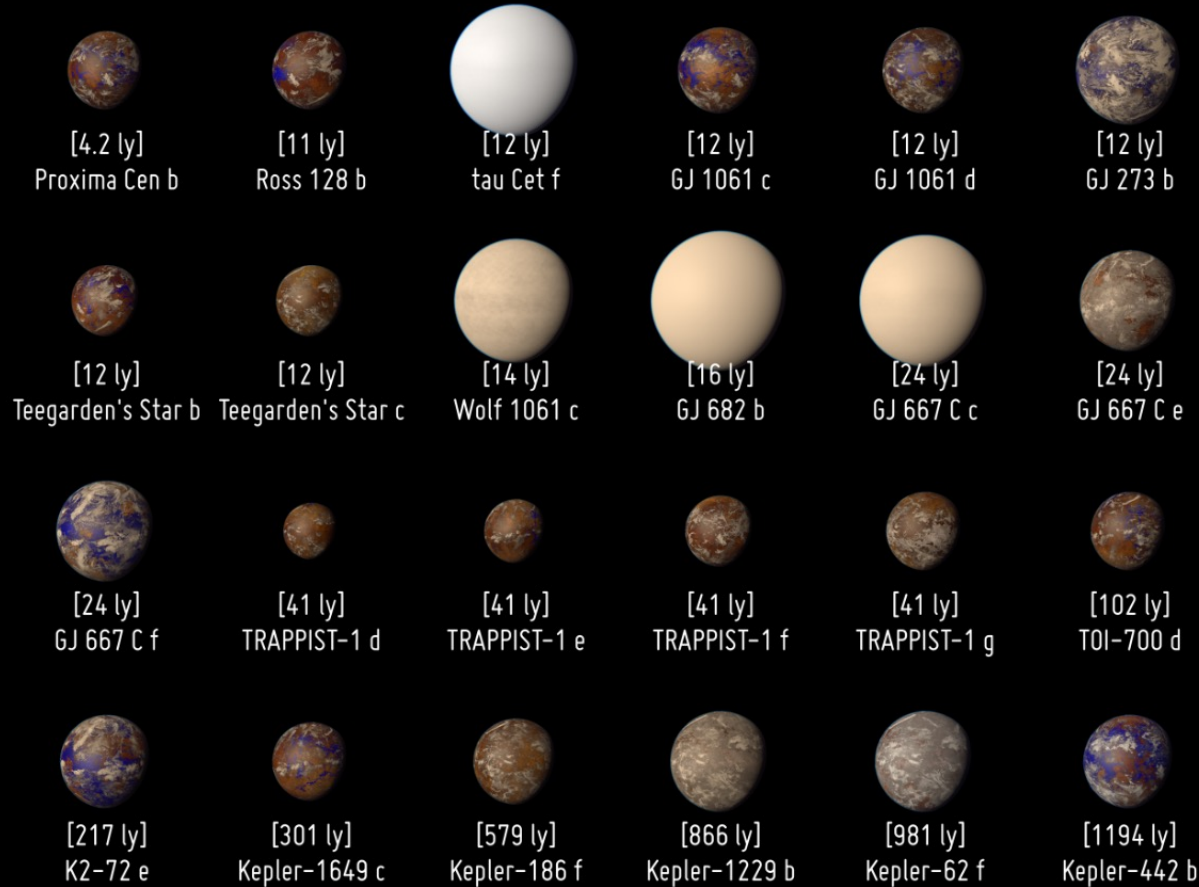
# Habitable zone for exoplanets



# Potentially Habitable Exoplanets



Ranked by Distance from Earth (light years)

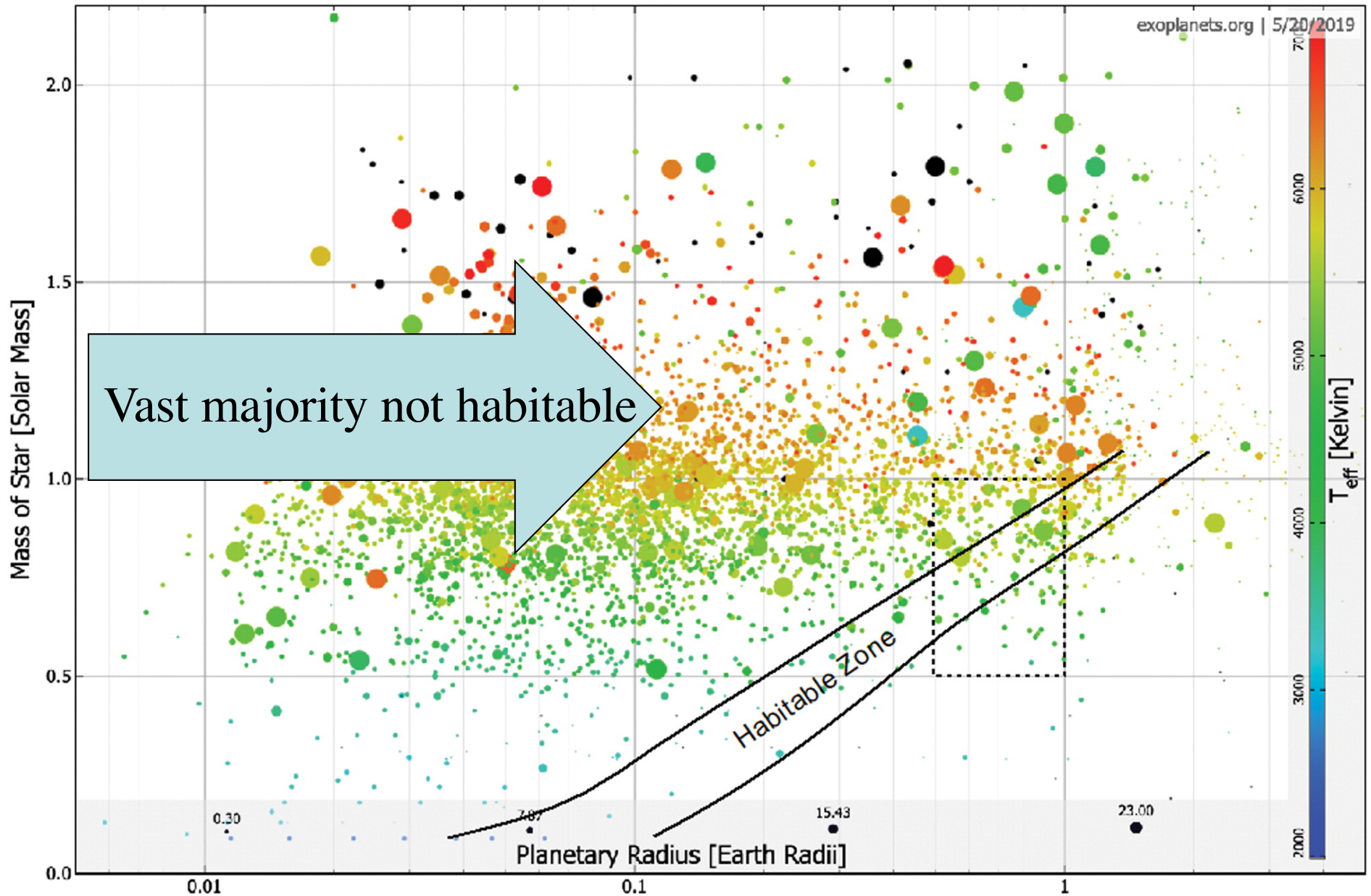


Artistic representations. Earth, Mars, Jupiter, and Neptune for scale. Distance from Earth is between brackets.

CREDIT: PHL @ UPR Arcibo (phl.upr.edu) Oct 5, 2020



Estimated total number of exoplanets in Milky Way: 100 Billion  
Confirmed exoplanets : ~4500  
Discovered exoplanets in habitable zone: ~30



# New challenge:

- Find exoplanets in habitable zone
- with atmosphere
- and oxygen in it

Are there any exomoons discovered yet?

There is one possible detection

Are there any rogue planets discovered yet?

There are ~10 rogue planets discovered with microlensing  
They float on their own without a host star through the Galaxy

50 Bill. Rouge planets are expected in the Galaxy