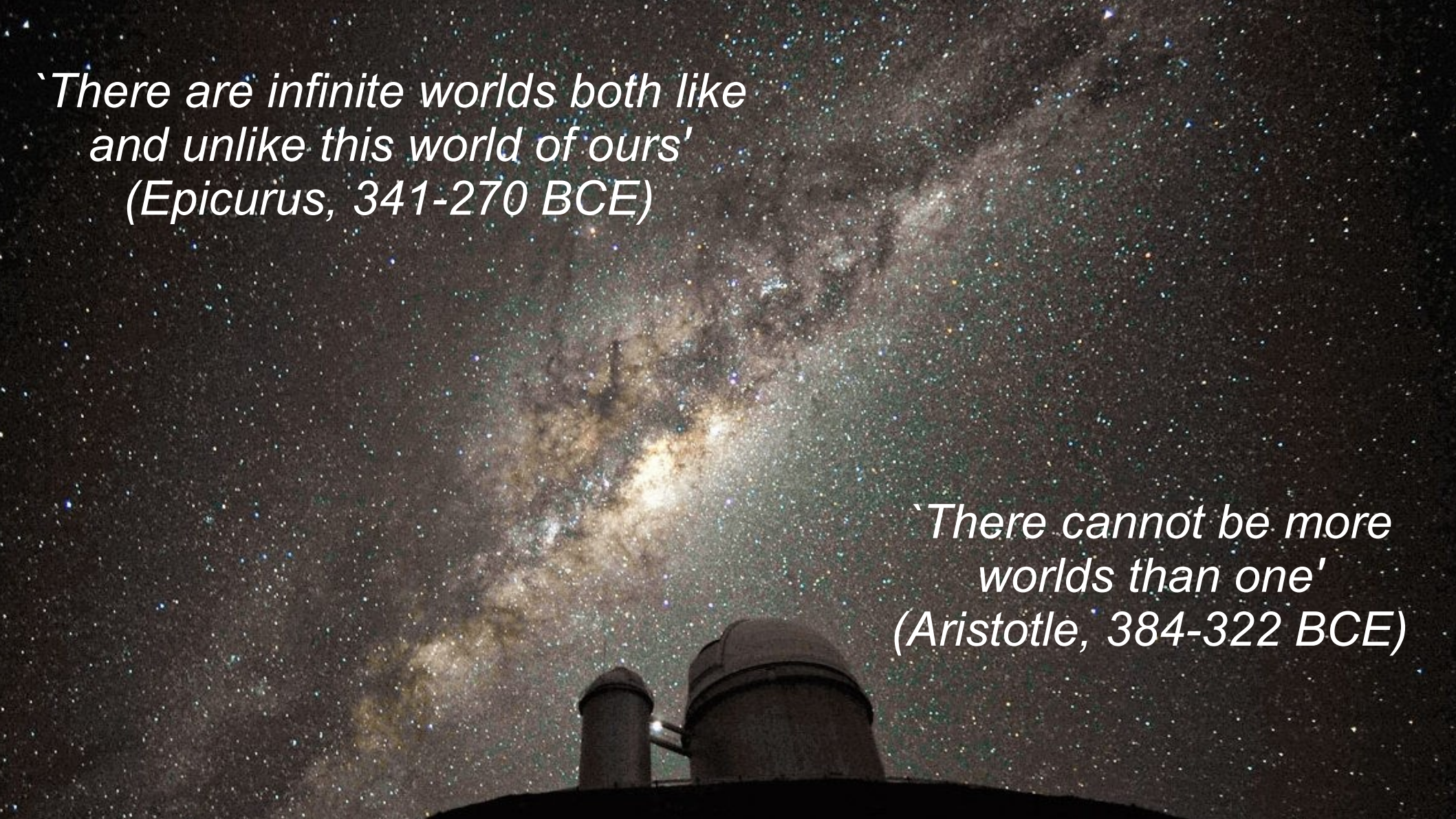




# Detecting Exoplanets: other worlds beyond our Solar System

Annelies Mortier

Credit:  
NASA Exoplanet  
Travel Bureau.

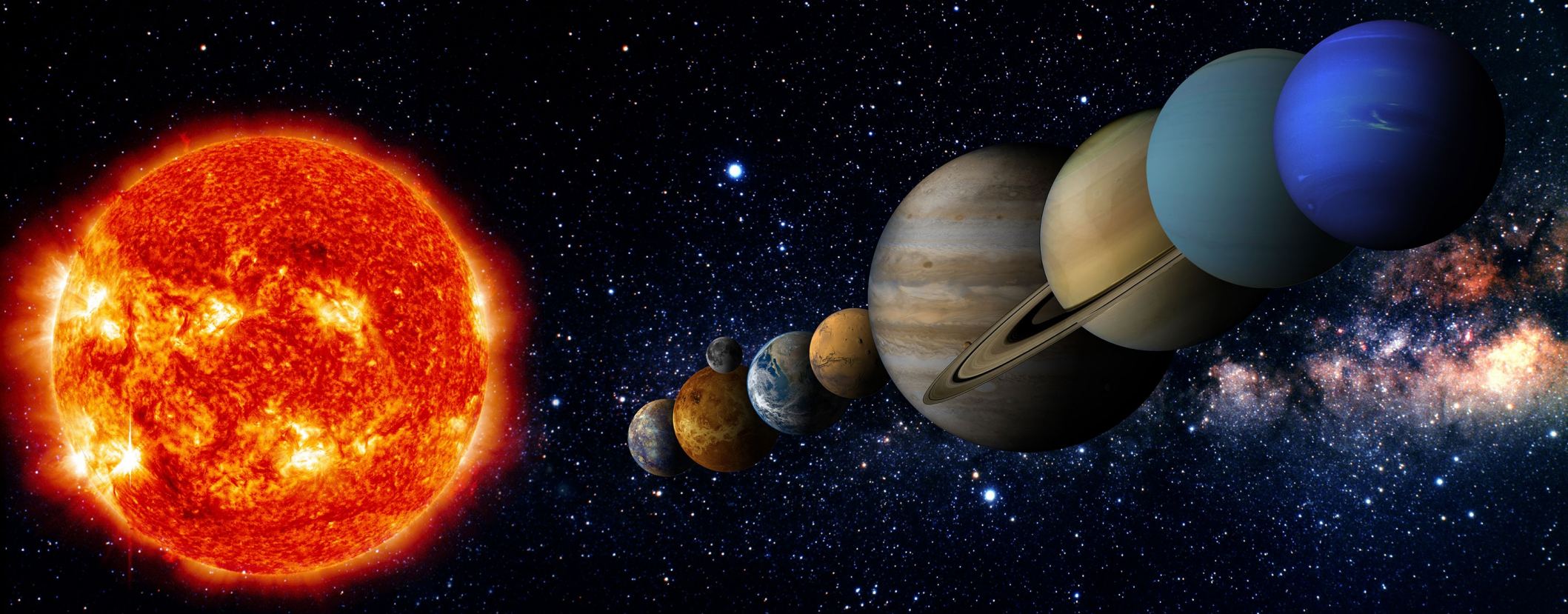


*'There are infinite worlds both like  
and unlike this world of ours'  
(Epicurus, 341-270 BCE)*

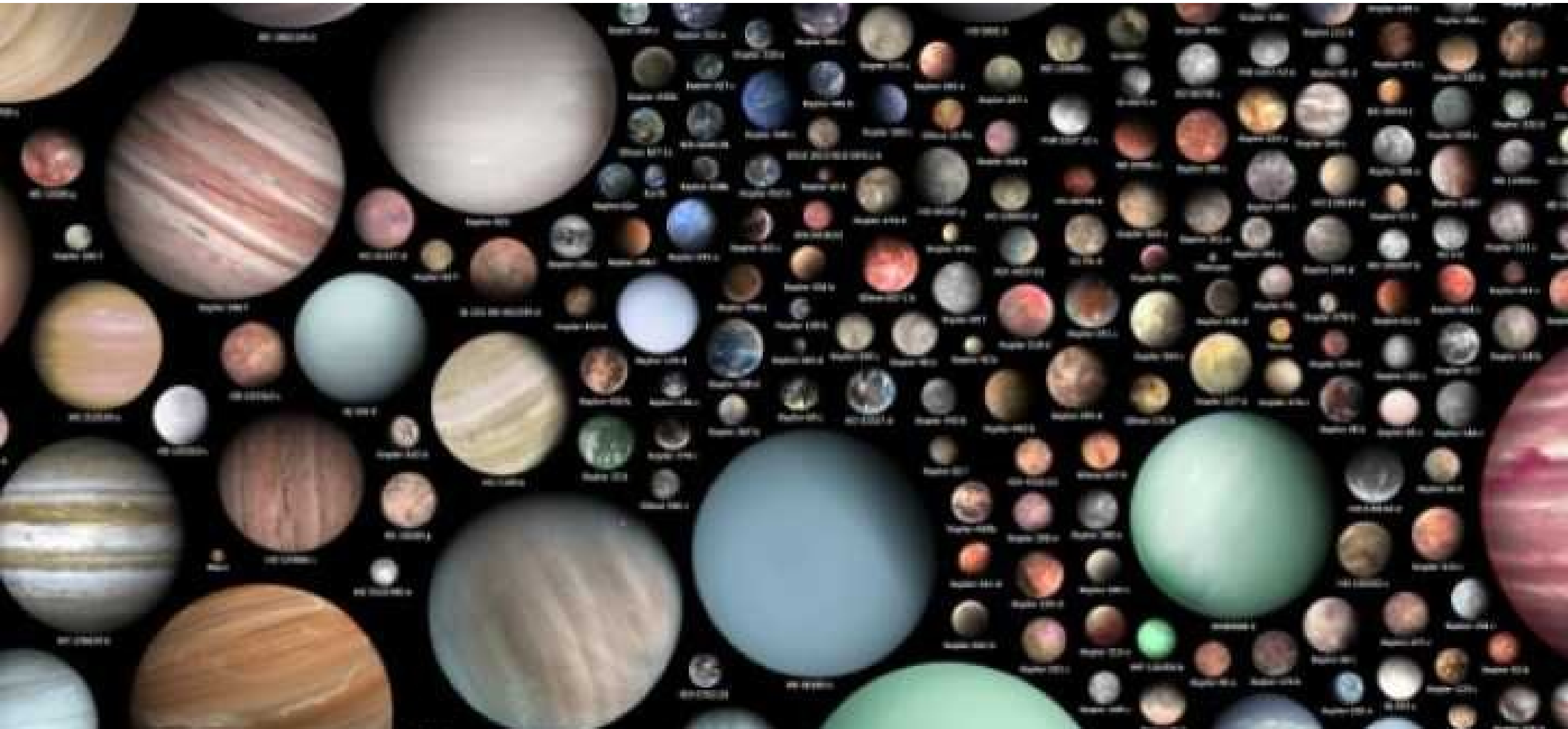
*'There cannot be more  
worlds than one'  
(Aristotle, 384-322 BCE)*

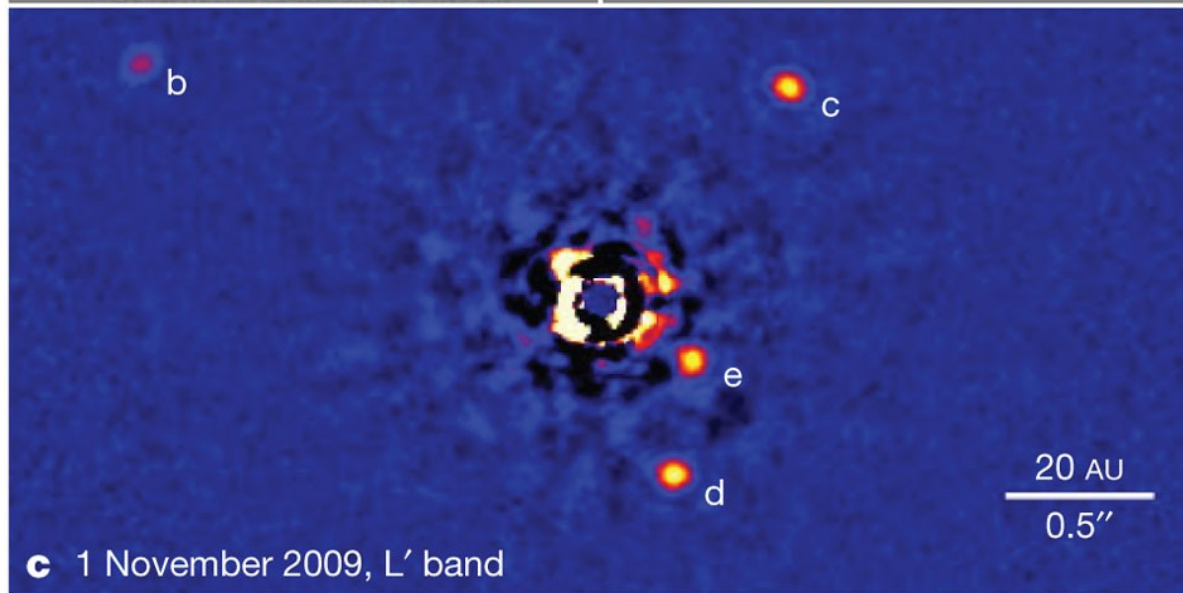
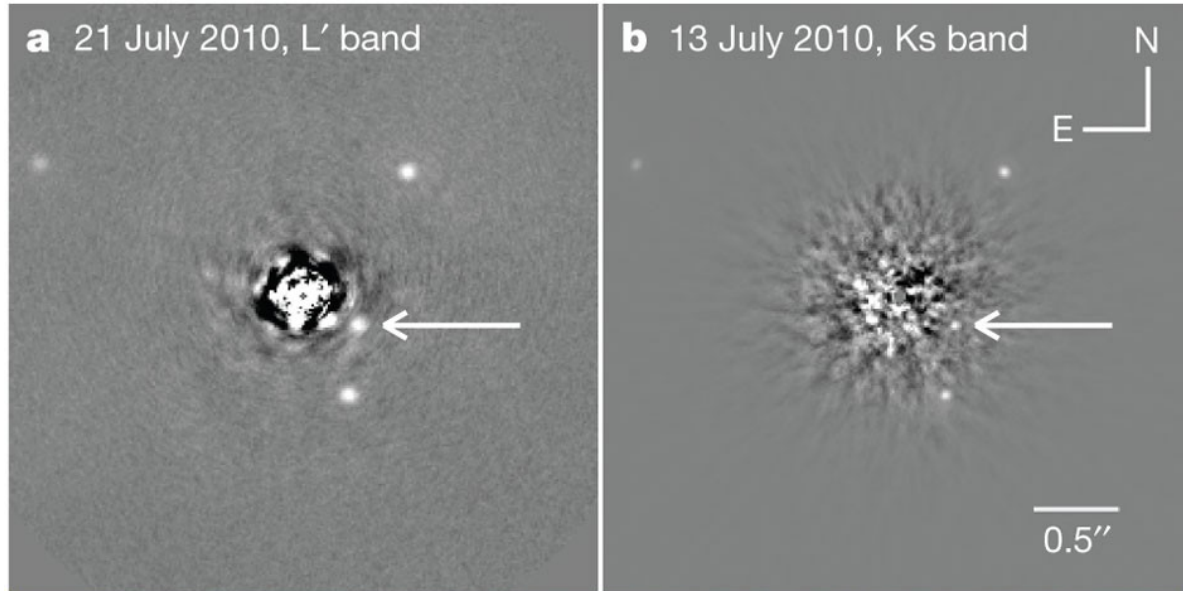


1991 – only knowledge of Solar System planets



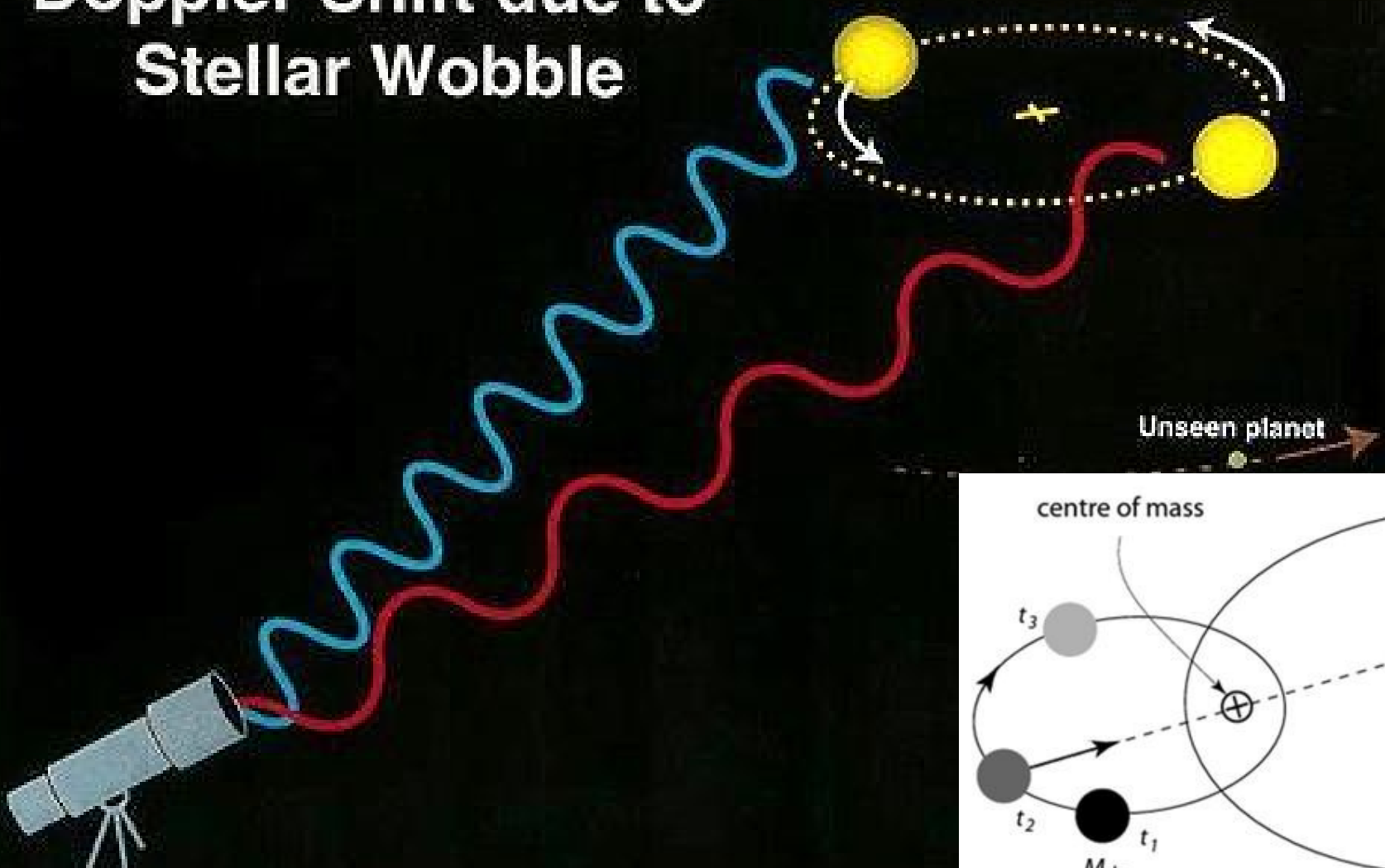
2022 – 5000+ exoplanets discovered



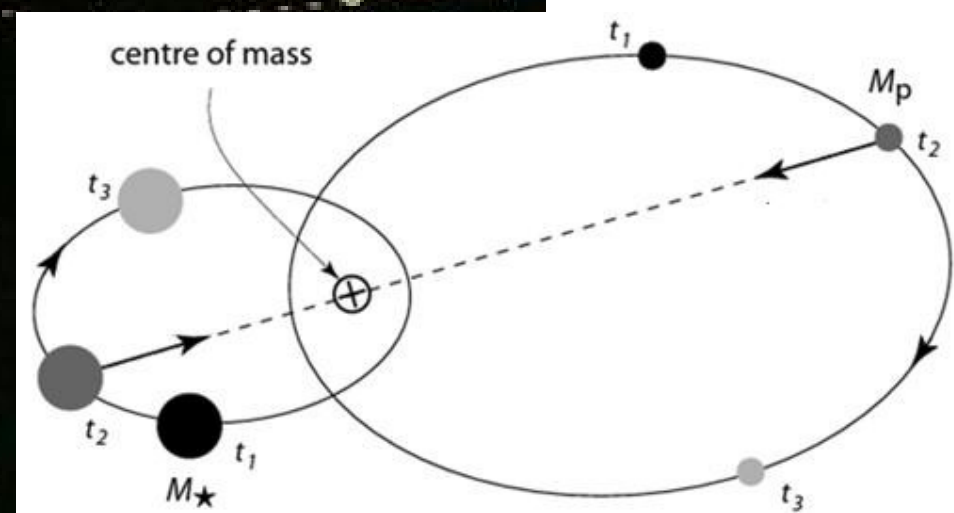


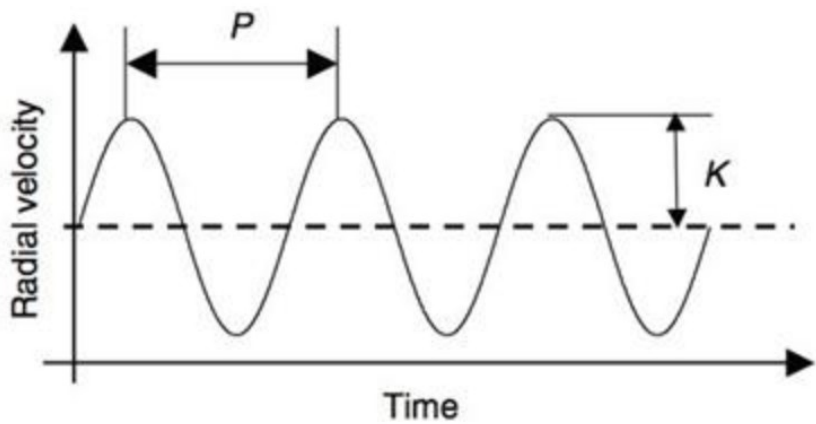
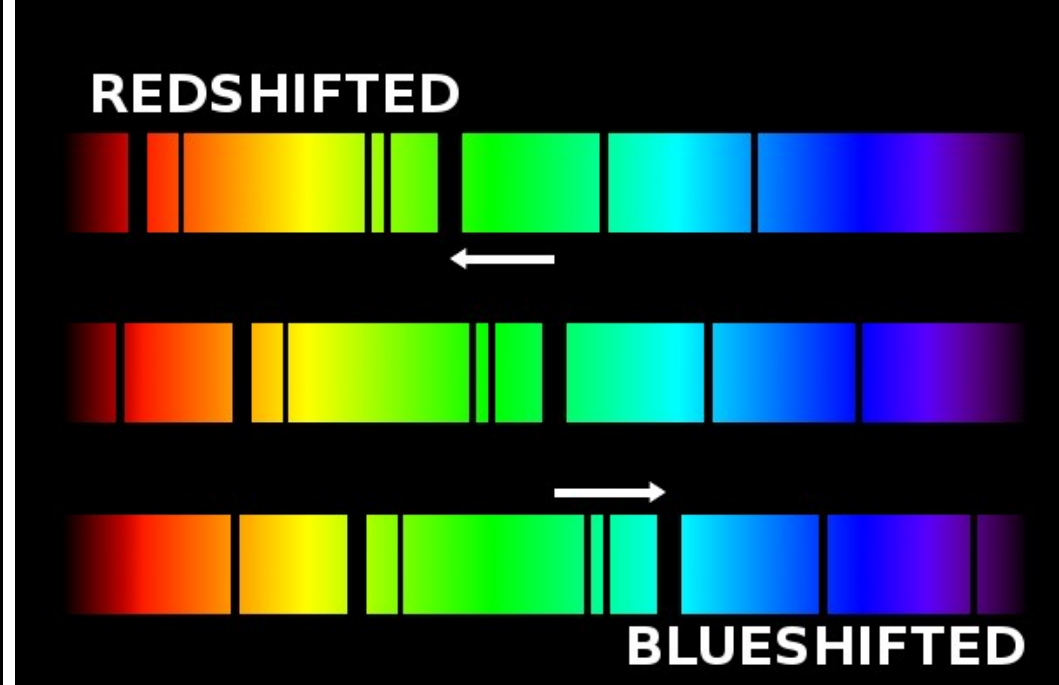
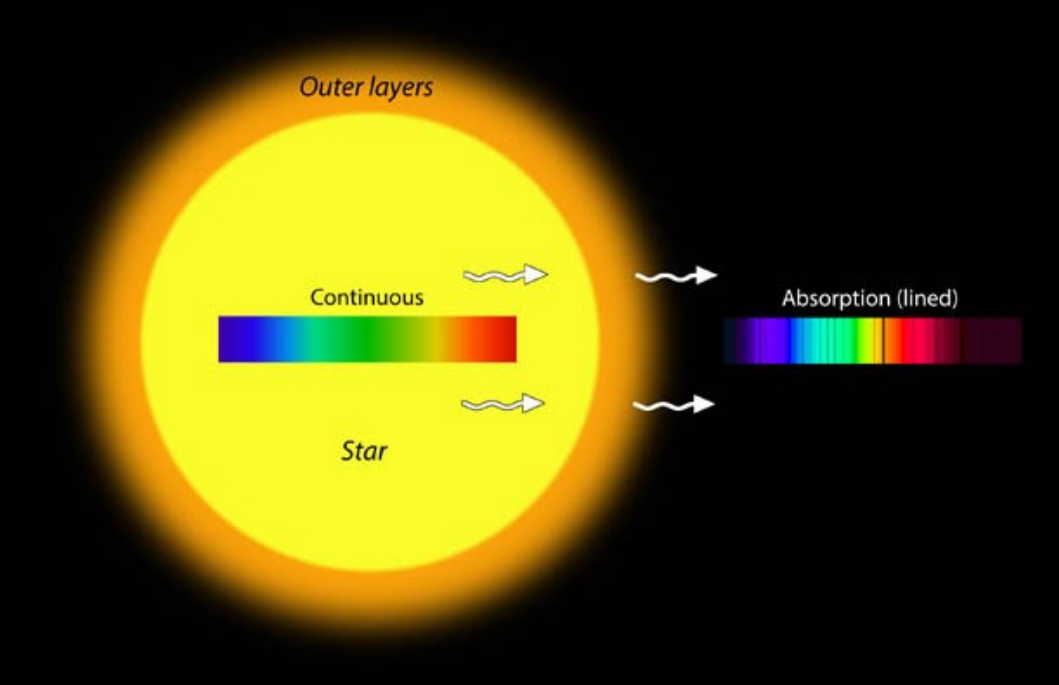


# Doppler Shift due to Stellar Wobble



# Radial Velocity



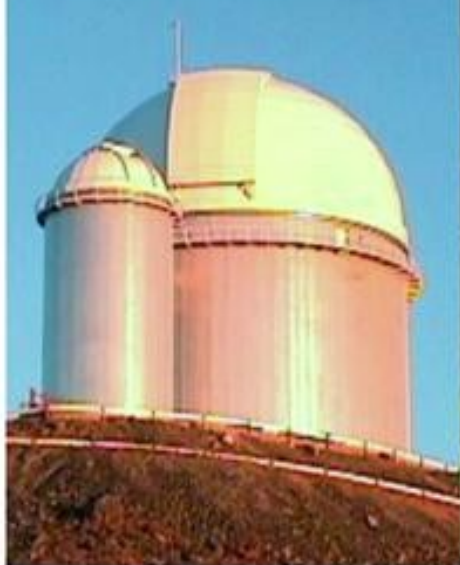


Jupiter around Sun

→  $K = 12.7 \text{ m/s}$  (~30 mph)

Earth around Sun

→  $K = 0.09 \text{ m/s}$  (~0.2 mph)





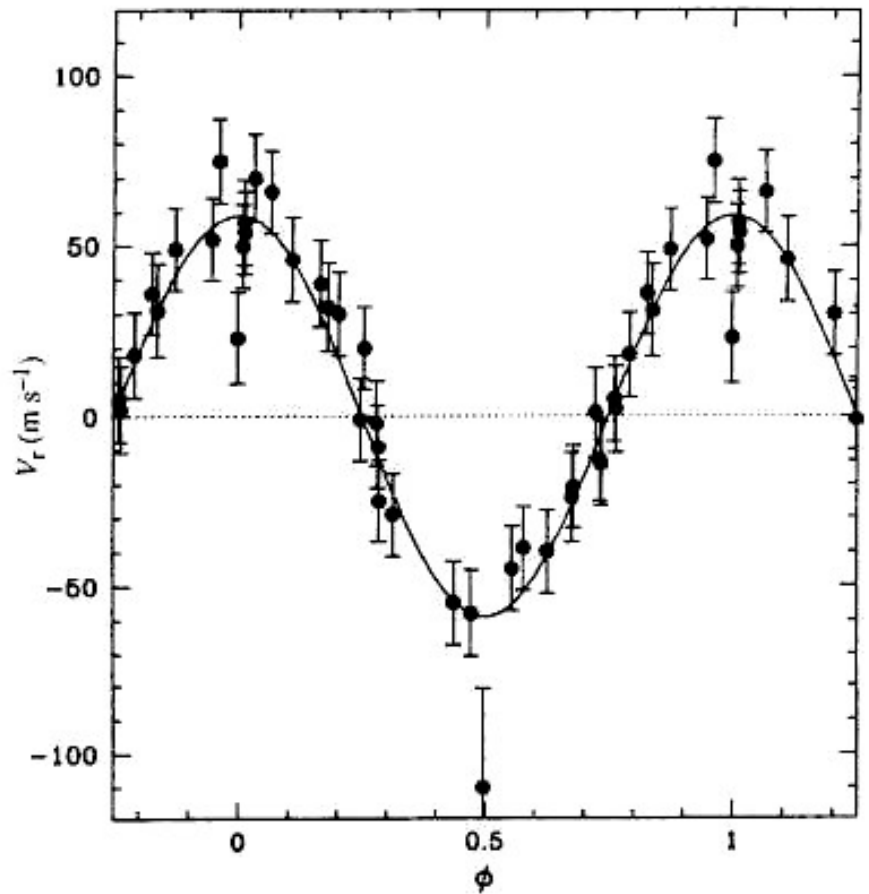




# 1995 – 51 Pegasi b – Mayor & Queloz

$P \sim 4$  days, Mass  $\sim 0.5 M_{JUP}$

We call these exoplanets *hot Jupiters*





# NOBELPRISET I FYSIK 2019 THE NOBEL PRIZE IN PHYSICS 2019



KUNGL.  
VETENSKAPS-  
AKADEMIEN

THE ROYAL SWEDISH ACADEMY OF SCIENCES

*"för bidrag till vår förståelse av universums utveckling och jordens plats i universum"*

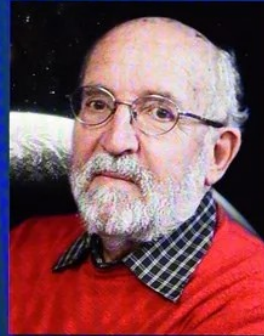
*"for contributions to our understanding of the evolution of the universe and Earth's place in the cosmos"*



**James Peebles**

*"för teoretiska upptäckter inom fysikalisk kosmologi"*

*"for theoretical discoveries in physical cosmology"*



**Michel Mayor**

*"för upptäckten av en exoplanet i bana kring en solliknande stjärna"*

*"for the discovery of an exoplanet orbiting a solar-type star"*

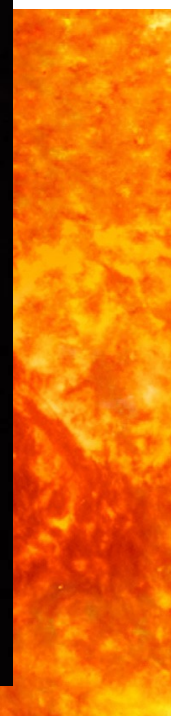


**Didier Queloz**

100  
50  
0  
-50  
-100

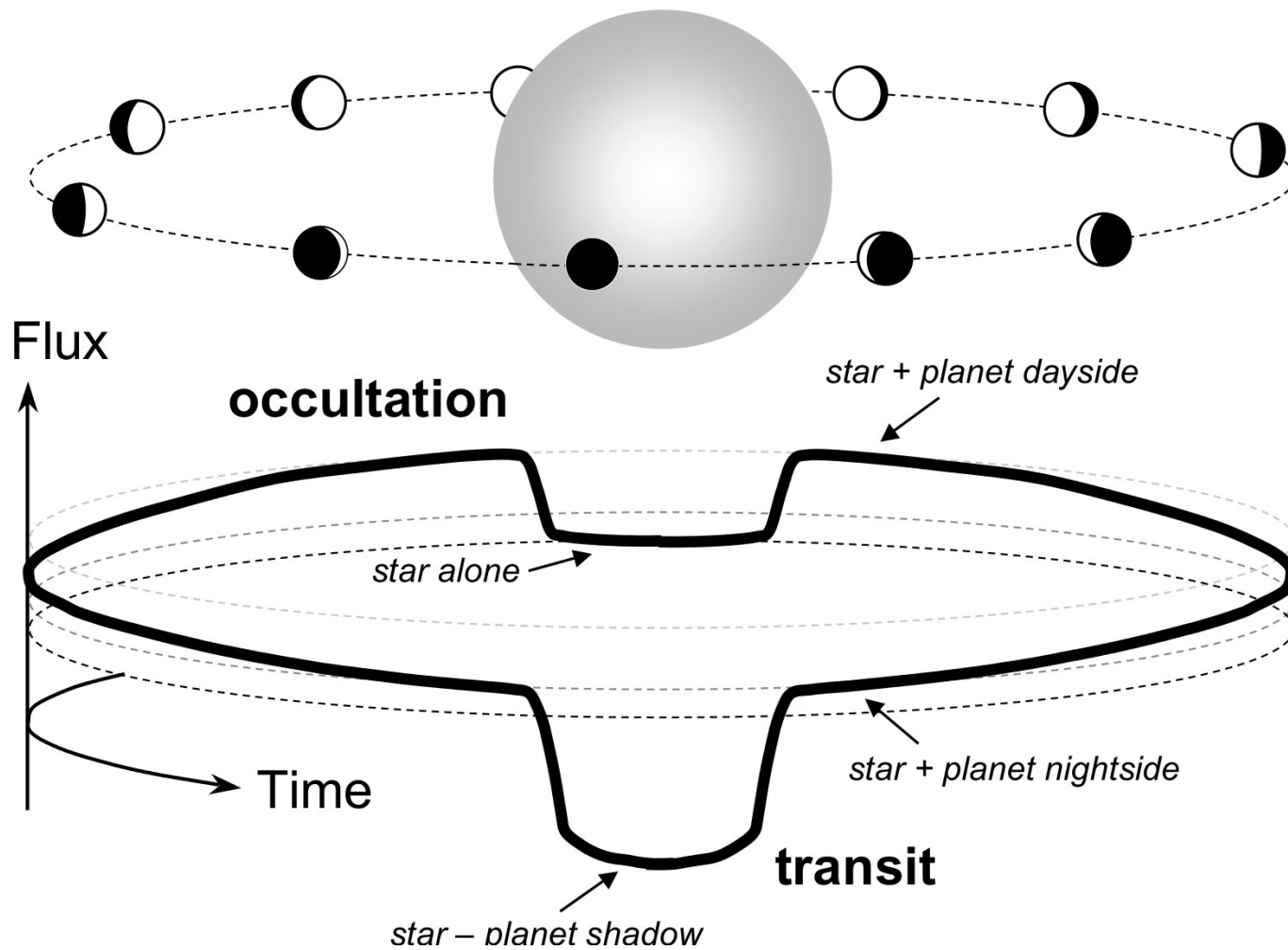
$V_r$  (m s<sup>-1</sup>)

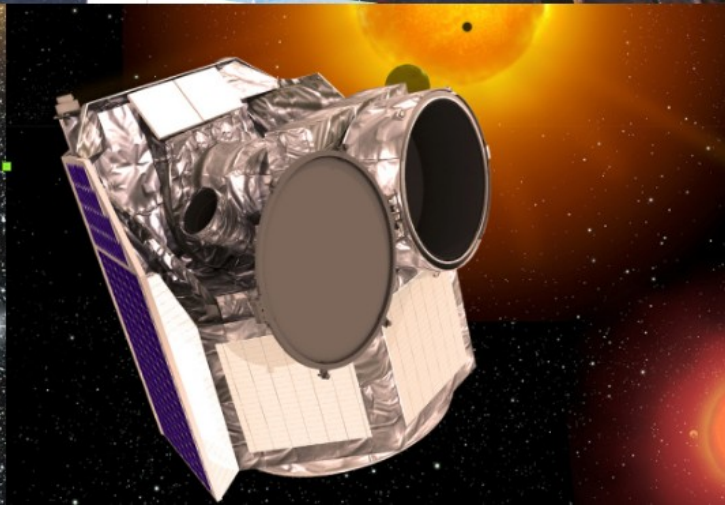
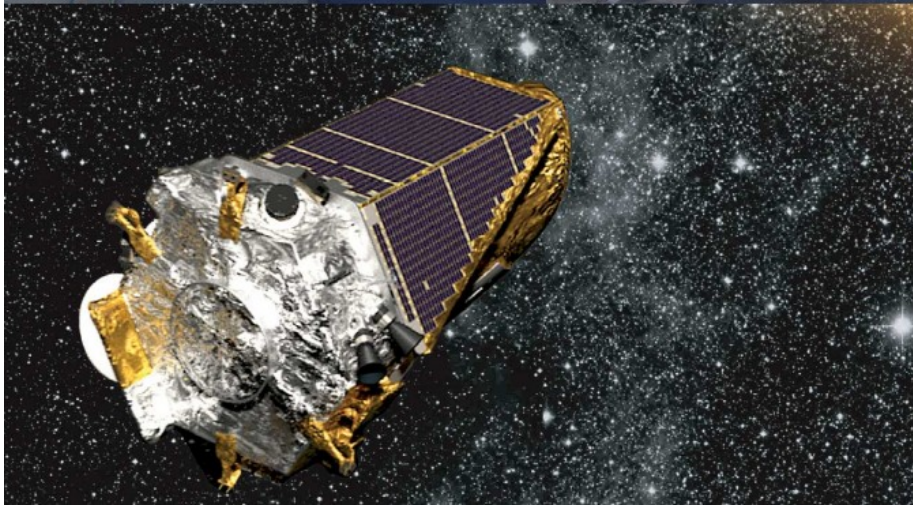
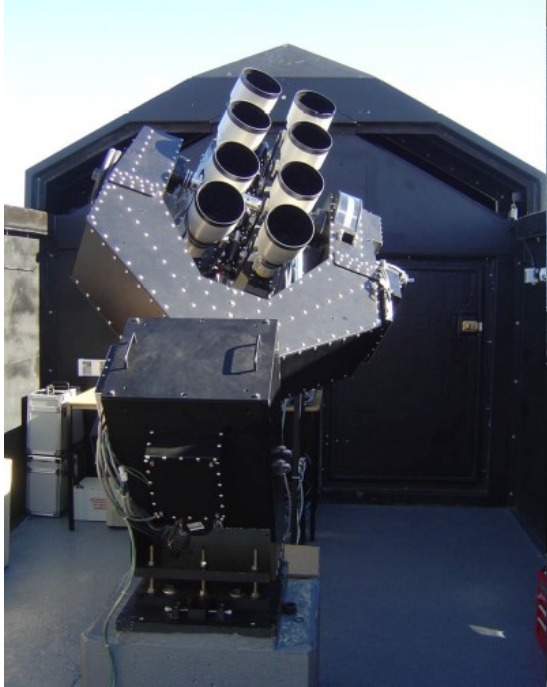
rs



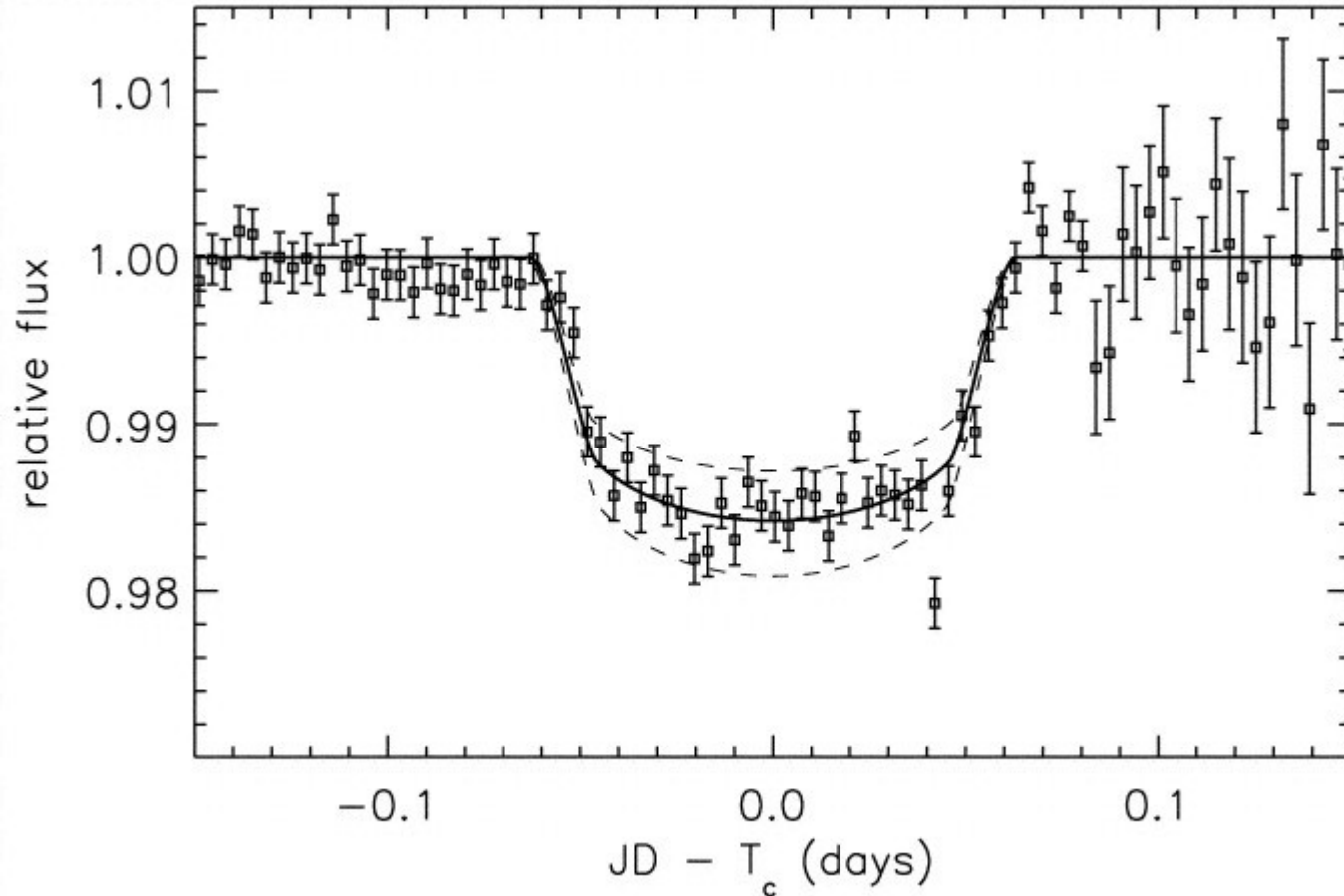


# Photometric transit





# 1999 – HD209458b – D. Charbonneau



$P \sim 3.5$  days

Radius  $\sim 1.4 R_{\text{jup}}$

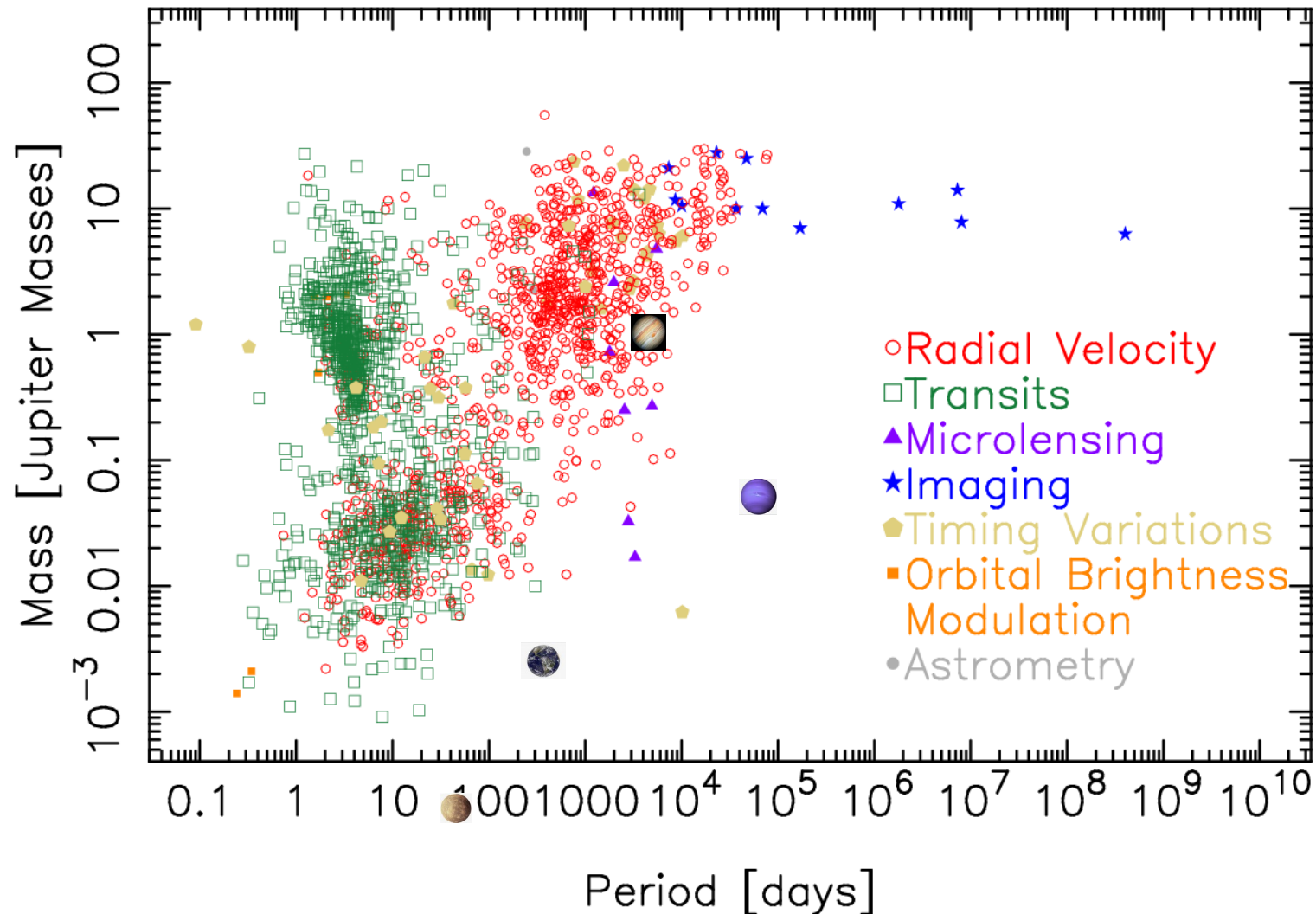
Again a  
*Hot Jupiter*



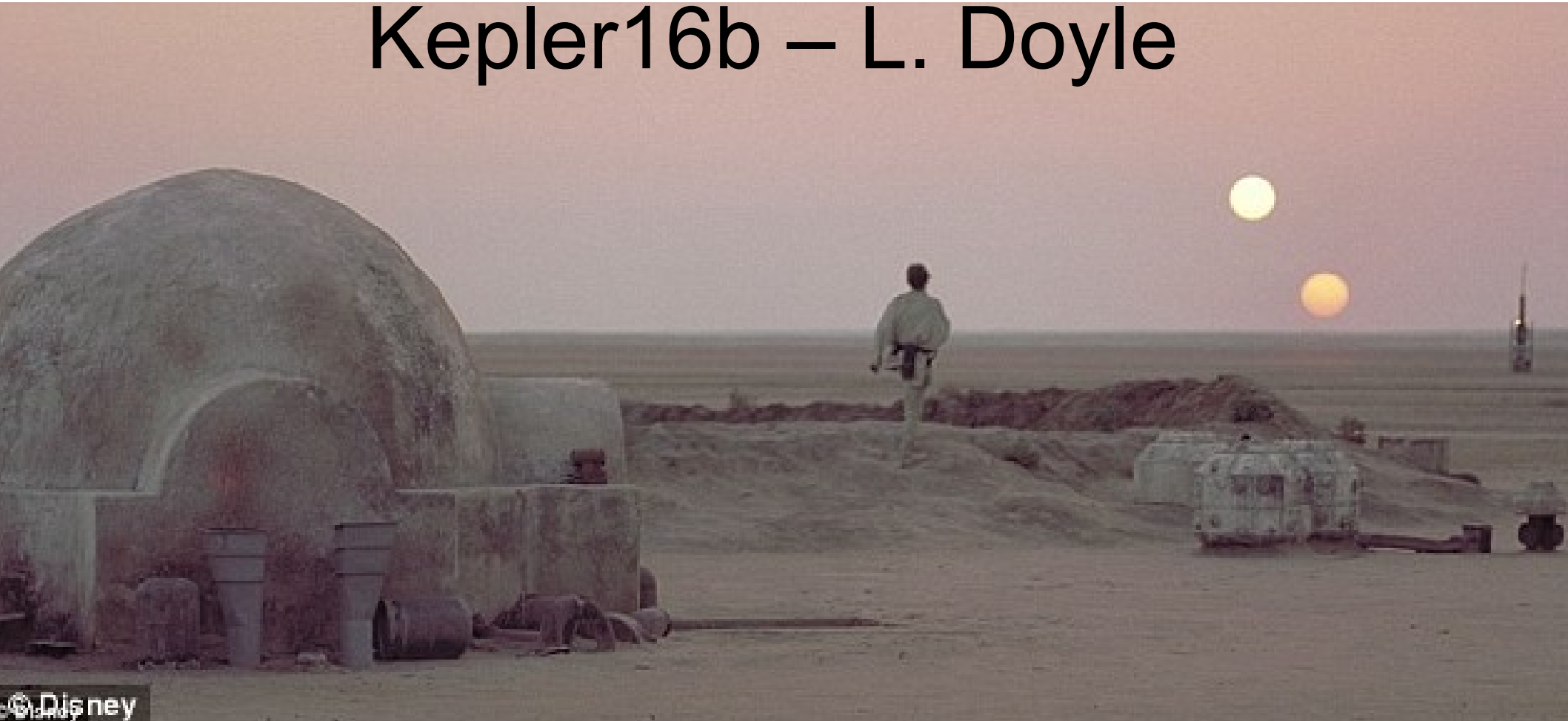
# Mass – Period Distribution

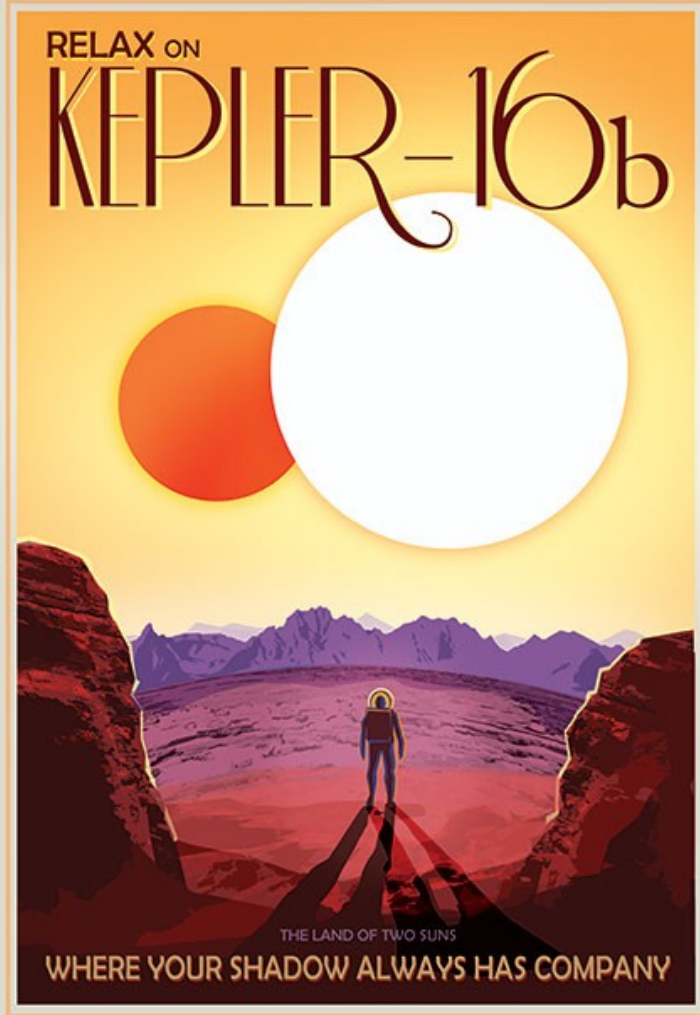
20 Oct 2022

exoplanetarchive.ipac.caltech.edu



# 2011 – Tatooine is “real” Kepler16b – L. Doyle





Like Luke Skywalker's planet "Tatooine" in Star Wars, Kepler-16b orbits a pair of stars. Depicted here as a terrestrial planet, Kepler-16b might also be a gas giant like Saturn. Prospects for life on this unusual world aren't good, as it has a temperature similar to that of dry ice. But the discovery indicates that the world's iconic double-sunset is anything but science fiction.

NASA's Exoplanet Explorer Program, Jet Propulsion Laboratory, Pasadena, CA  
www.jpl.nasa.gov



Discovered in October 2013 using direct imaging, PSO J318.5-22 belongs to a special class of planets called rogue, or free-floating, planets. Wandering alone in the galaxy, they do not orbit a parent star. Not much is known about how these planets come to exist, but scientists theorize that they may be either failed stars or planets ejected from very young systems after an encounter with another planet. These rogue planets glow faintly from the heat of their formation. Once they cool down, they will be dancing in the dark. Confirmed and candidate exoplanets and all available data are listed in the NASA Exoplanet Archive.

NASA's Exoplanet Explorer Program, Jet Propulsion Laboratory, Pasadena, CA  
www.jpl.nasa.gov

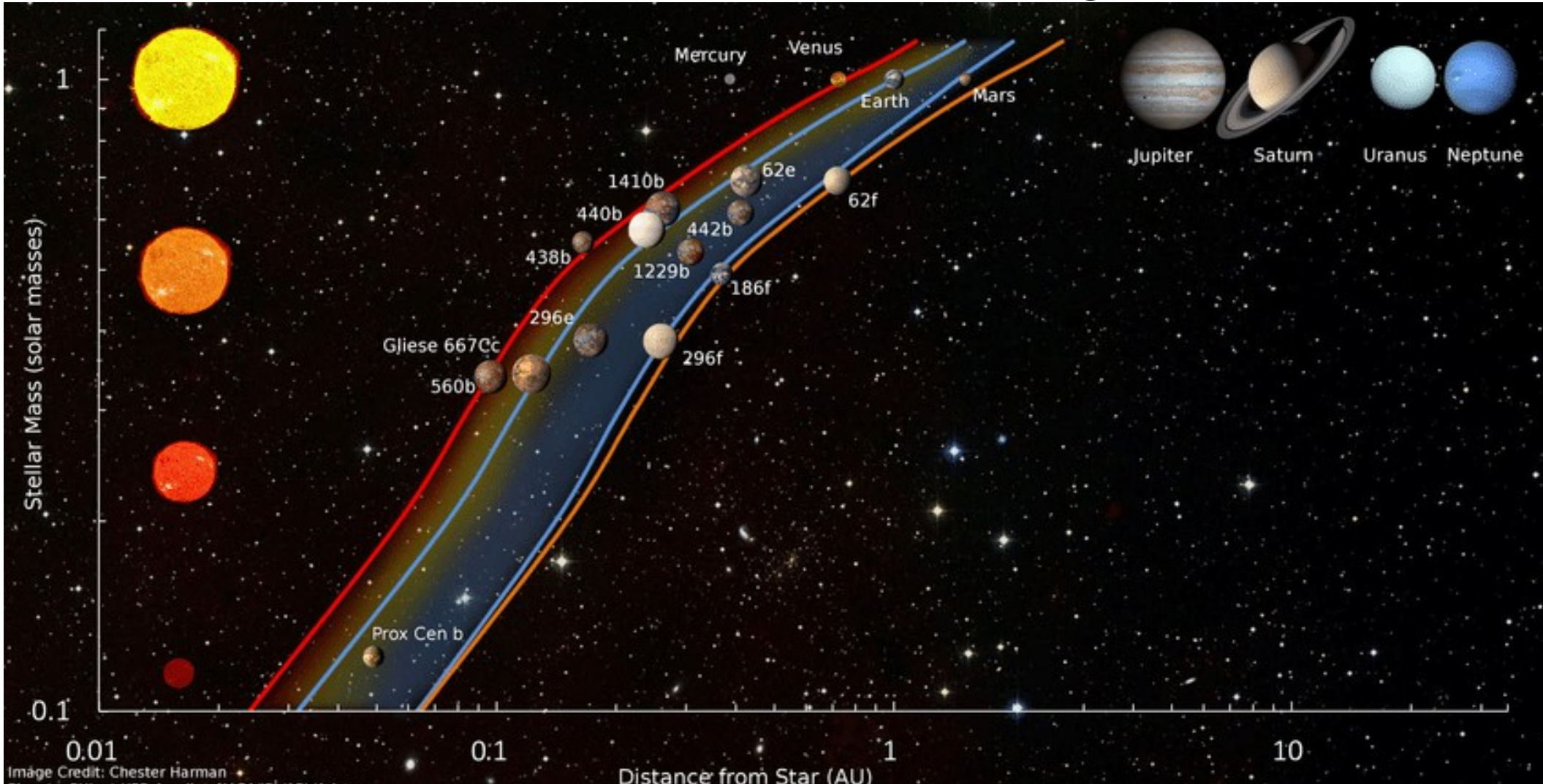
NASA's  
Exoplanet  
Travel  
Bureau



# 2012 – the start of citizen planet hunters

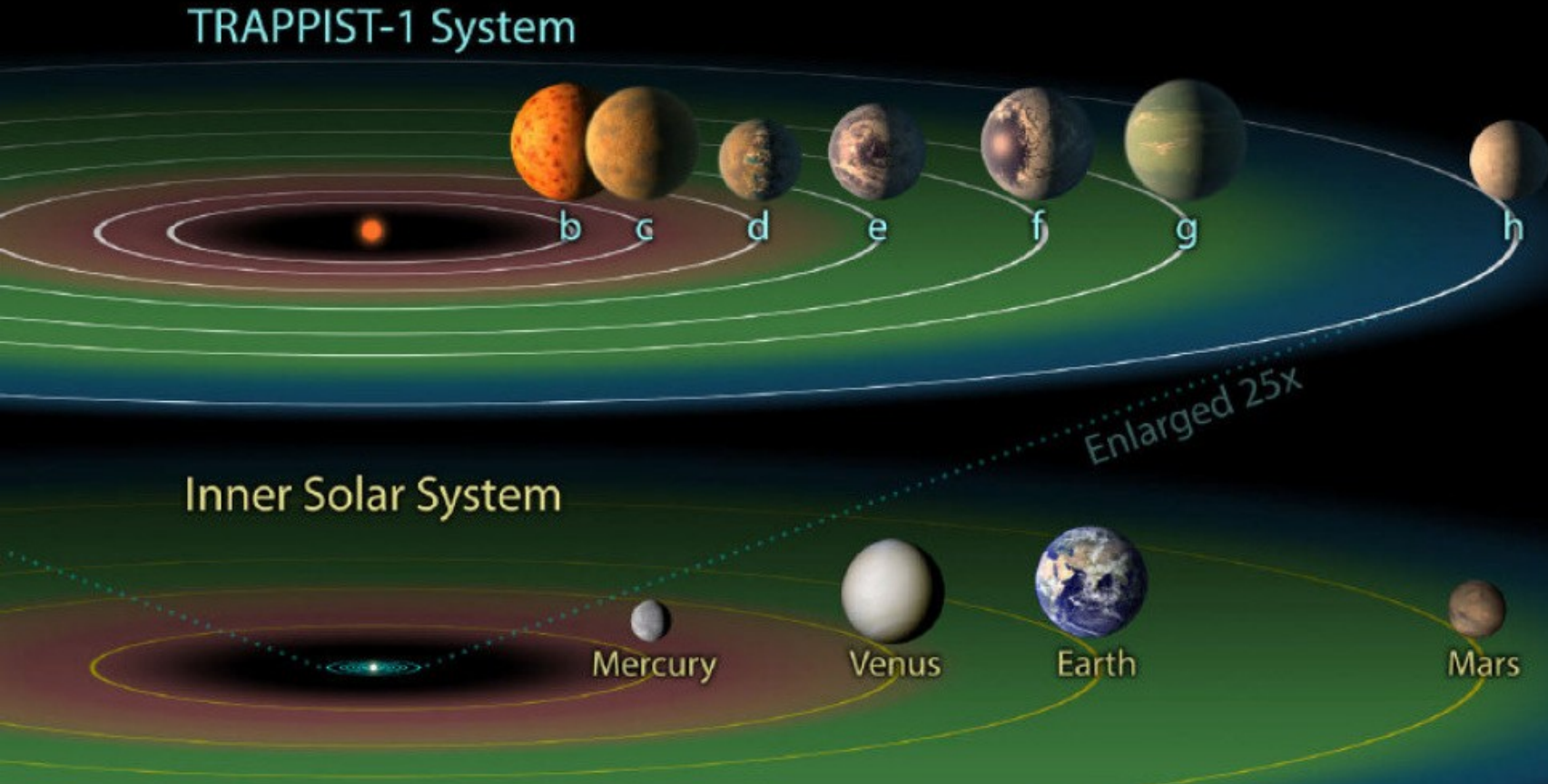


# 2016 – Proxima Centauri b – our neighbour planet





# 2017 – The TRAPPIST-1 system

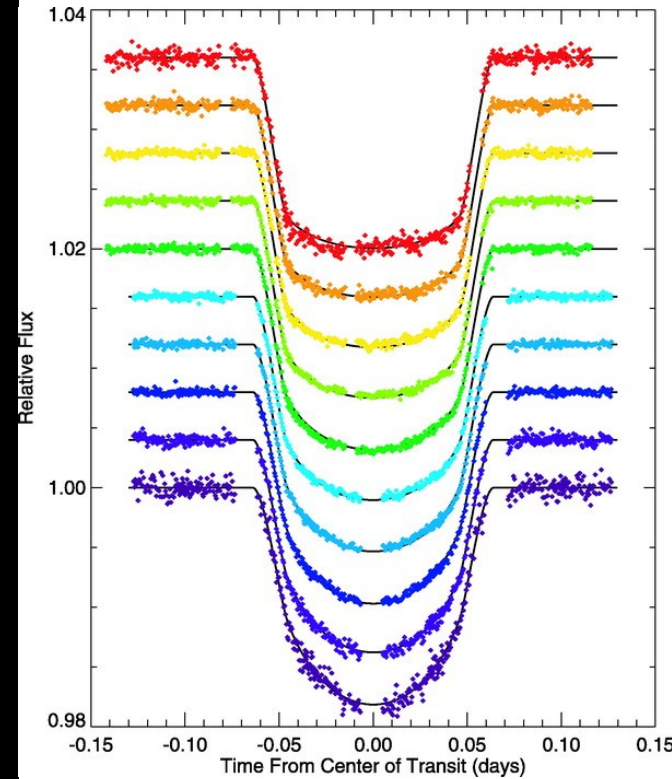
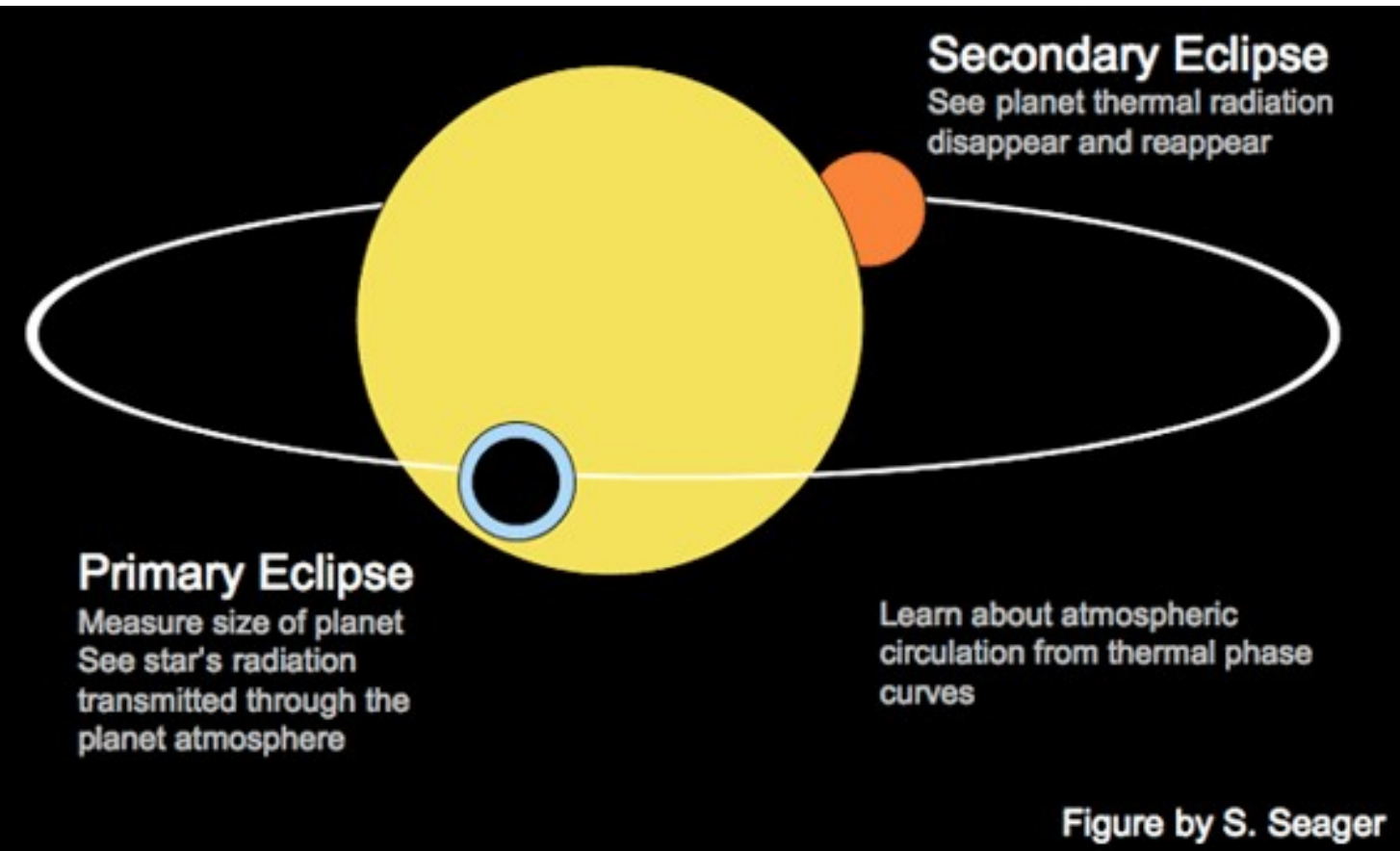




2021 – The James Webb Space Telescope is launched  
(as a Christmas present)



# Measuring planet atmospheres



Knutson et al. 2007



2030s?

