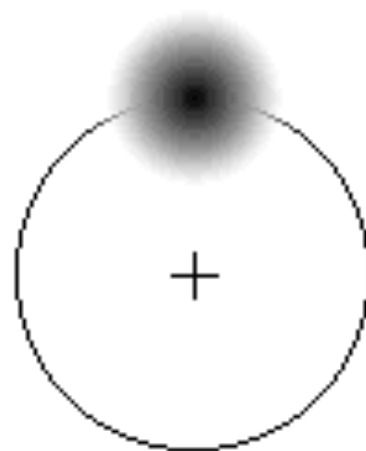


Exoplanets II



Observation of Stellar Motions Due to Presence of Extra-Solar Planet

Orbit of Star Around
System's Center of Mass
(Viewed from above)

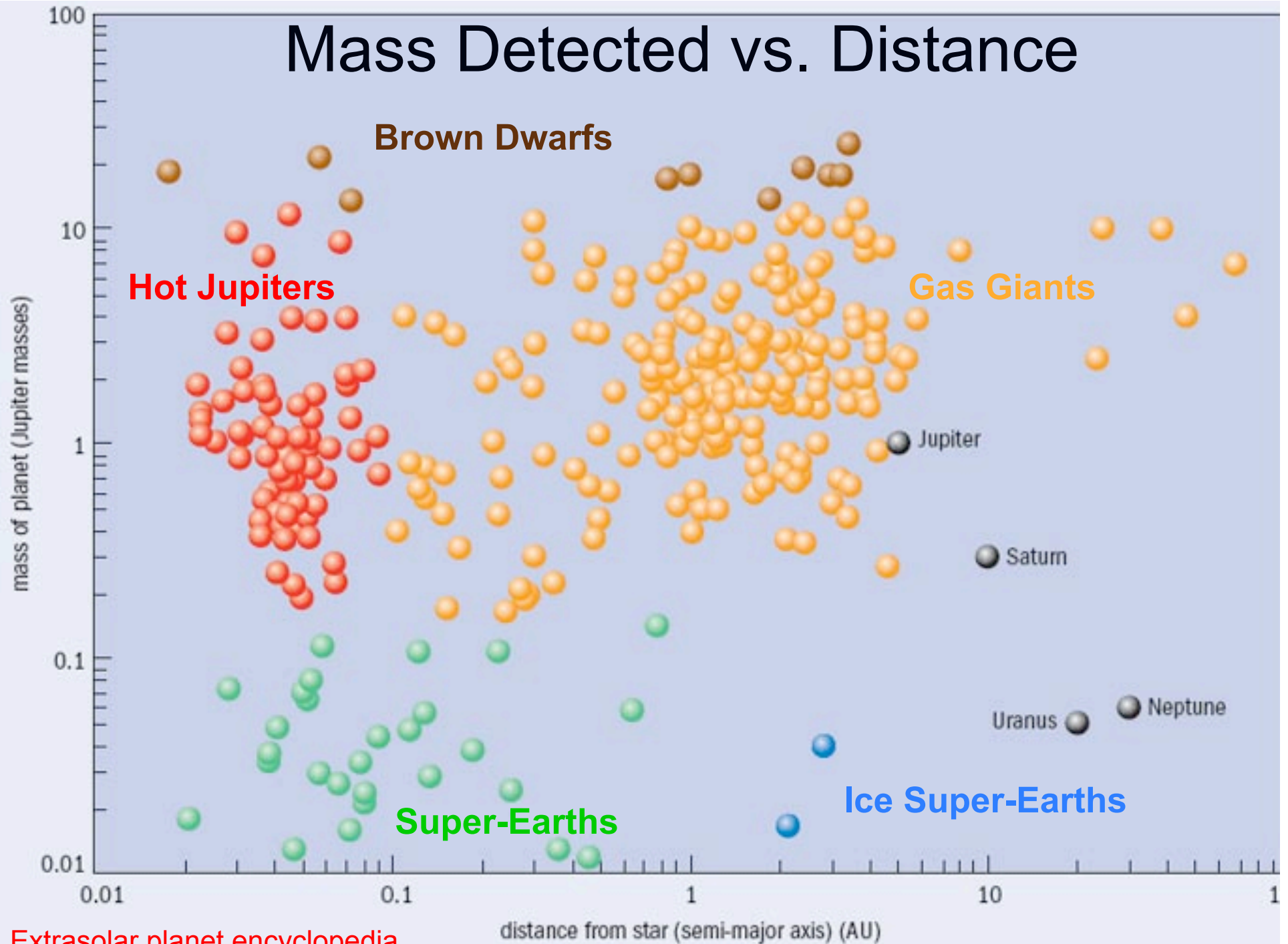


Earth
↓ ↓ ↓

Doppler Shift
(Detects movement *along*
line of sight)



Mass Detected vs. Distance



Planetary Transit Method

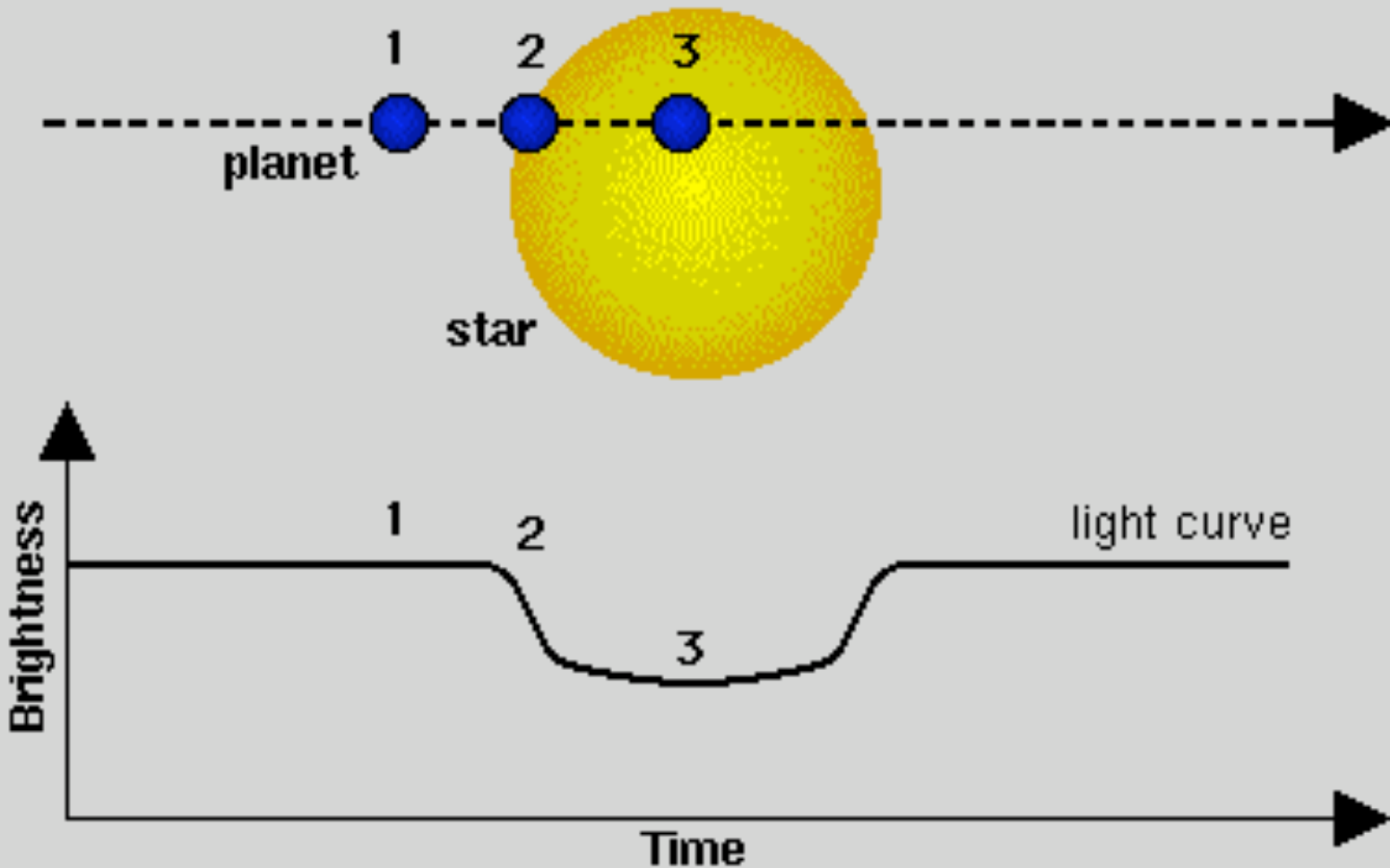
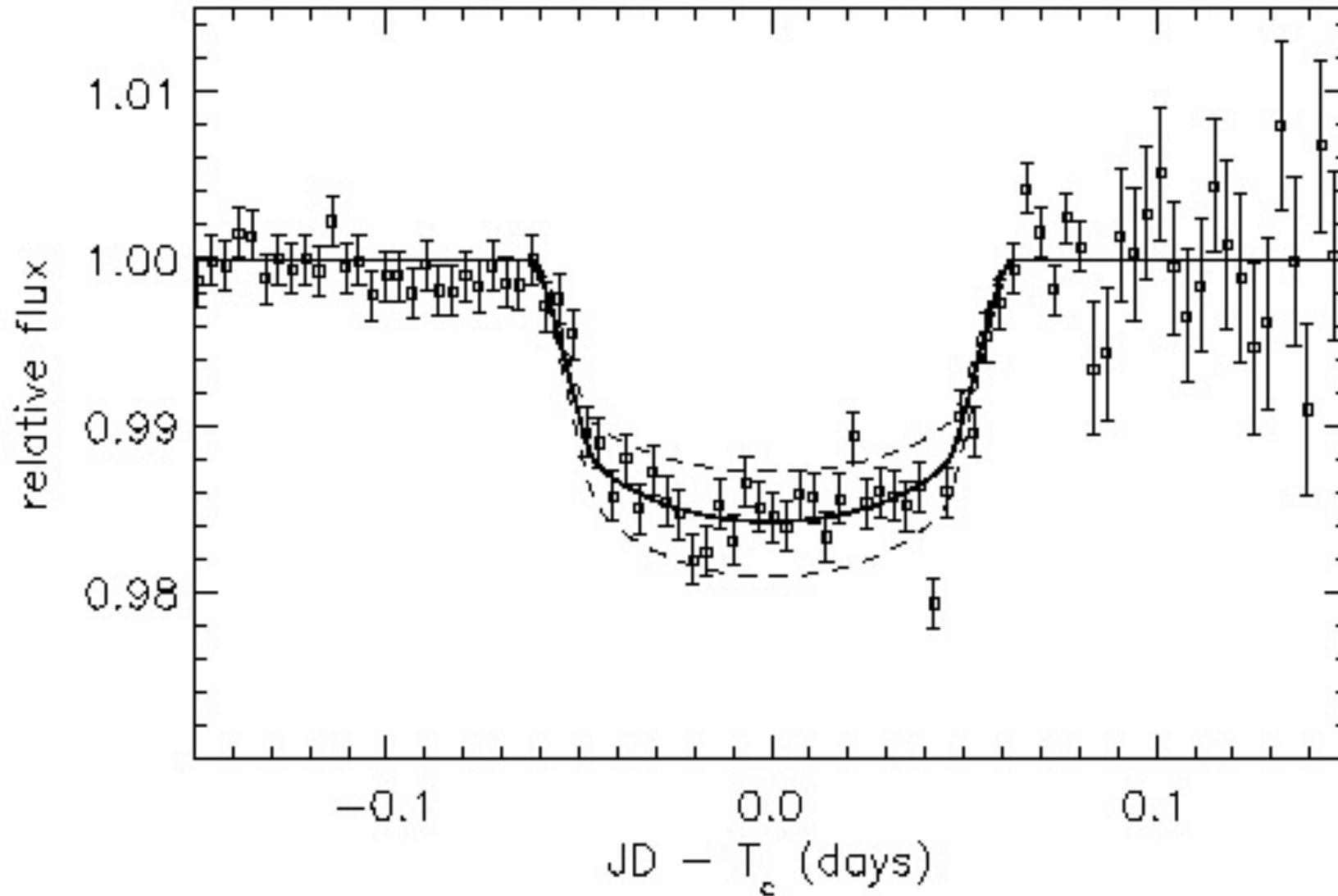


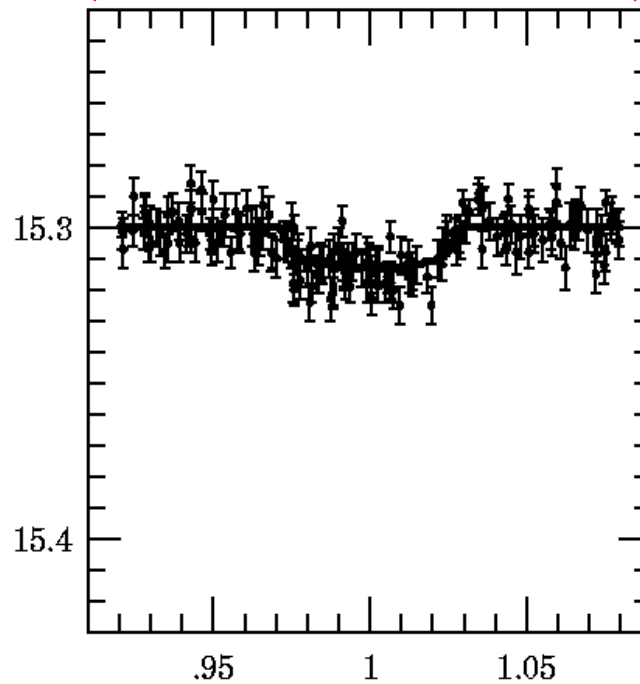
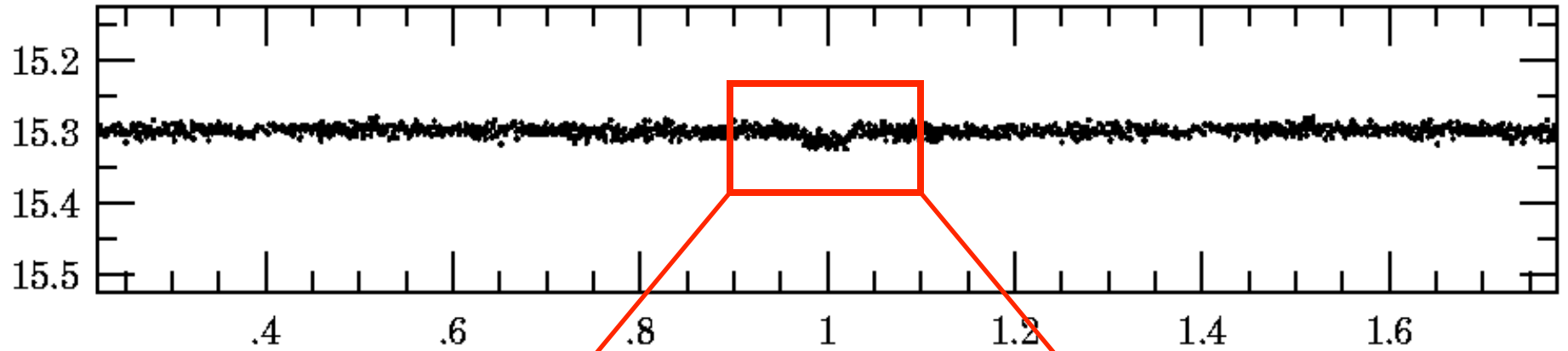
Figure based on one by Hans Deeg, from ['Transits of Extrasolar Planets'](#)

HD209458 - Transit + RV Discovery



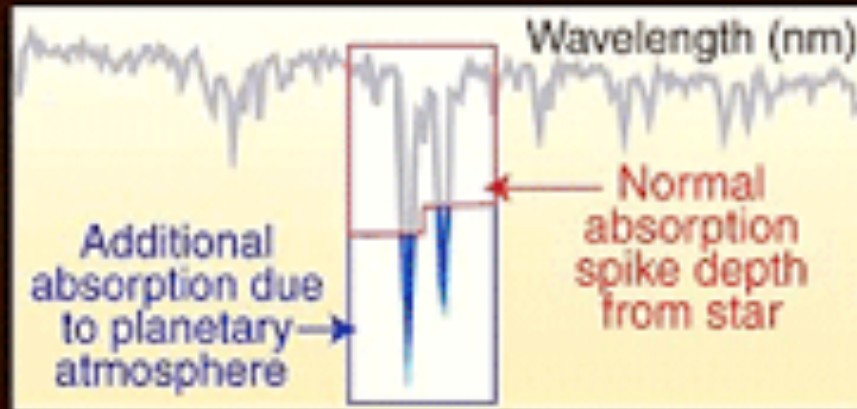
Transit Discovery

OGLE-TR-56 $P=1.21190$ (days)

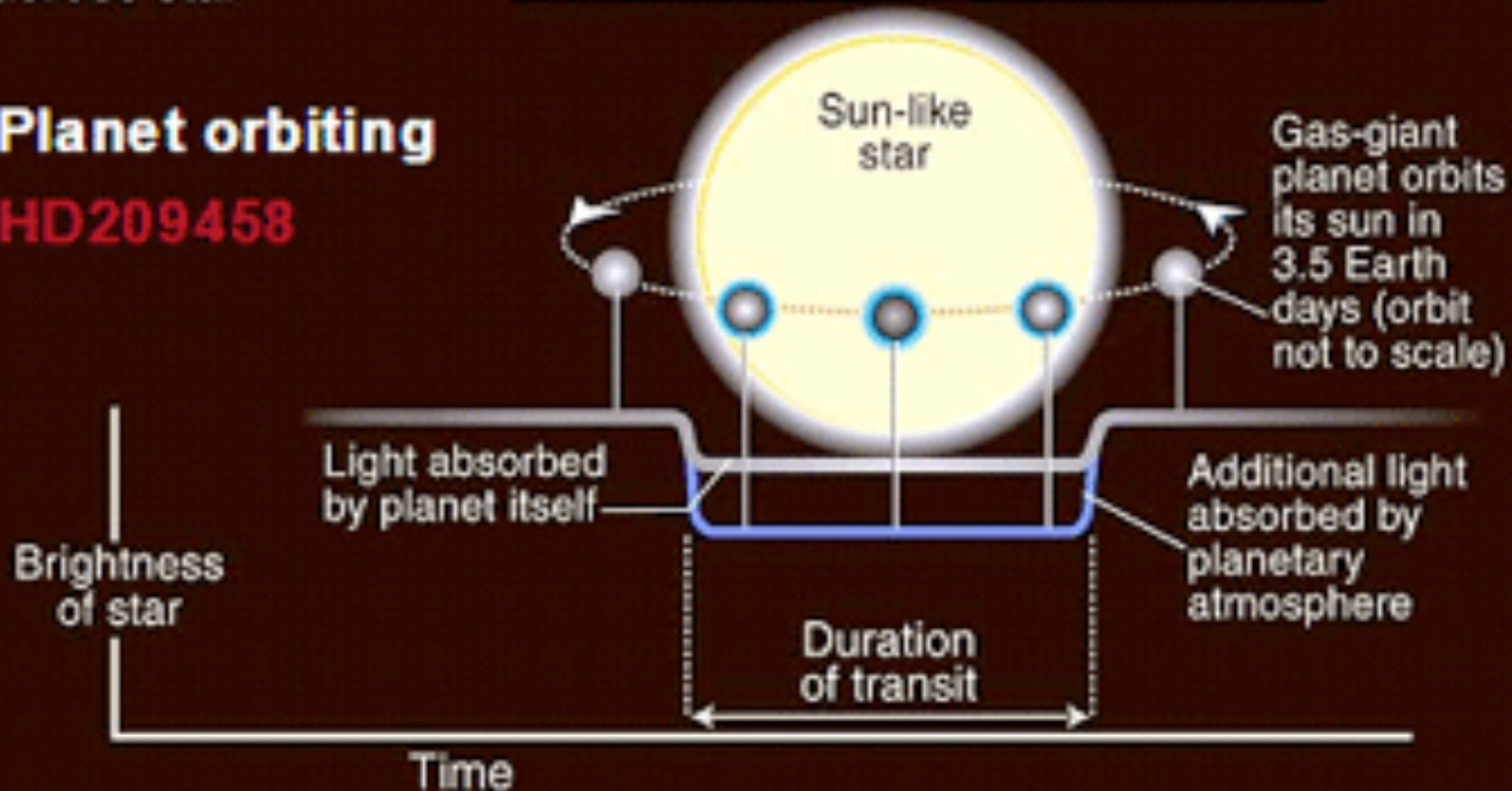


Detecting an atmosphere !

HST detects additional sodium absorption due to light passing through planetary atmosphere as planet transits across star

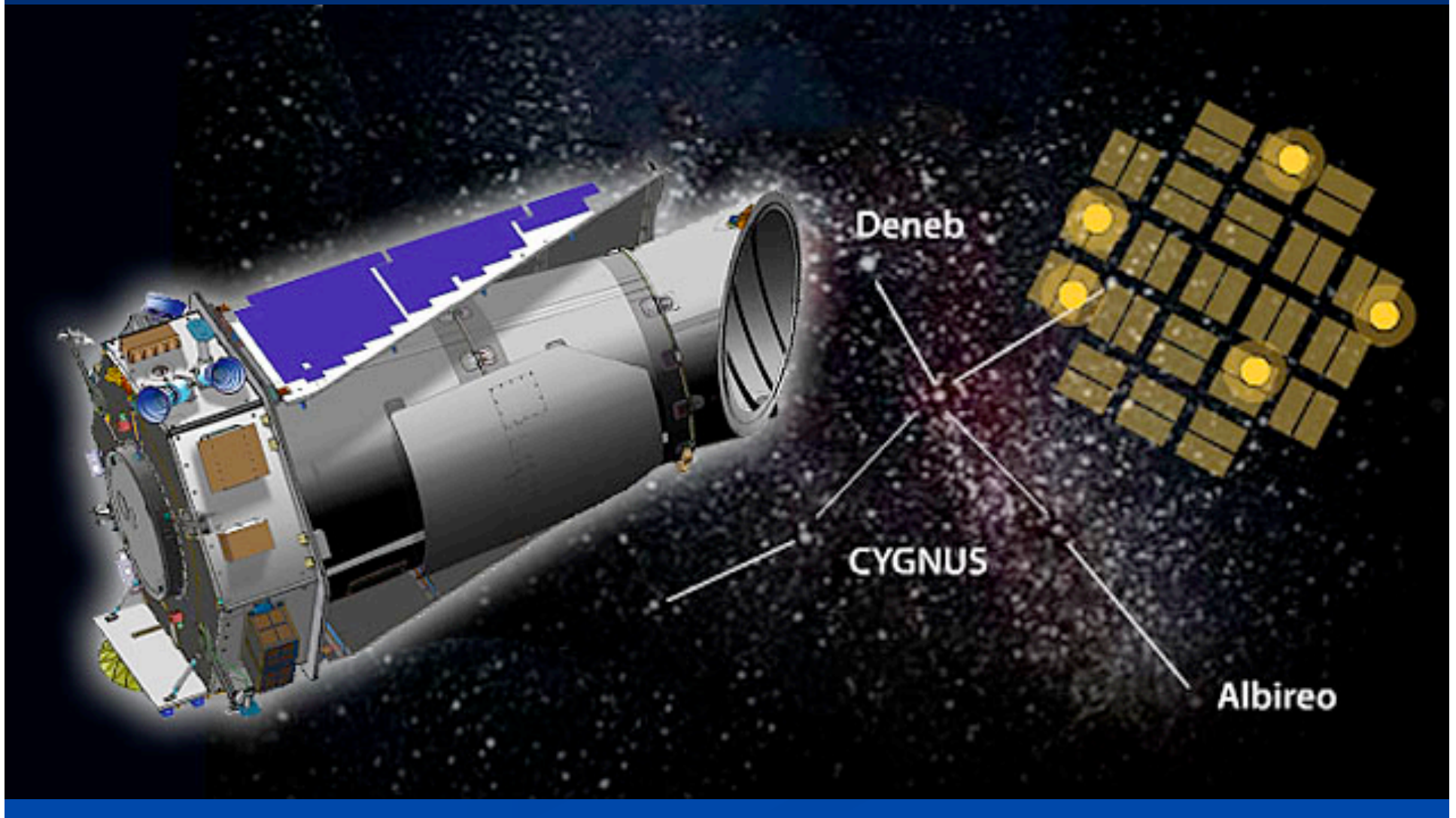


Planet orbiting
HD209458



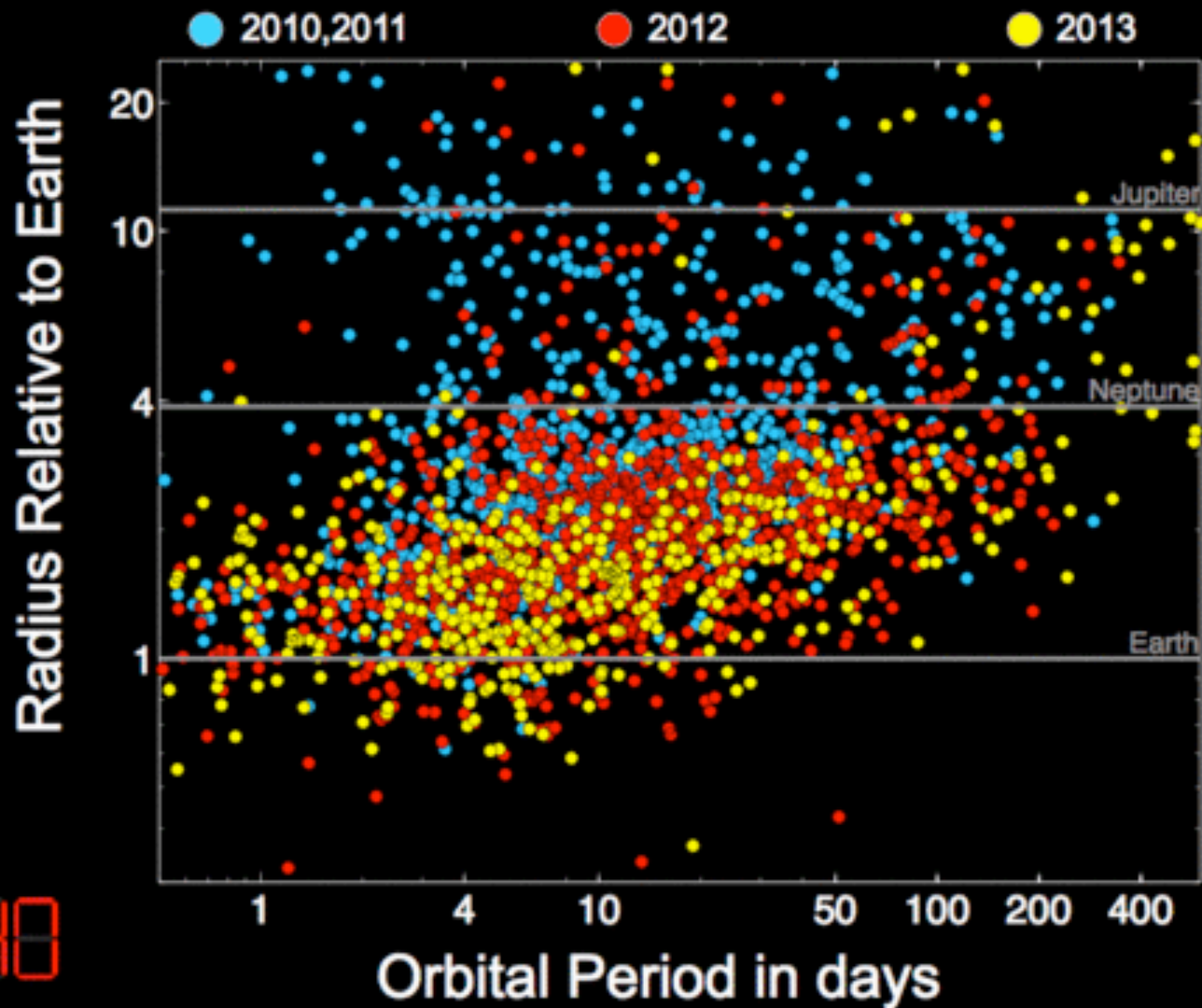
KEPLER Mission Launched March 2009!

Stare at same patch of sky for several years



Kepler's Planet Candidates

22 Months: May 2009 - Mar 2011



2740

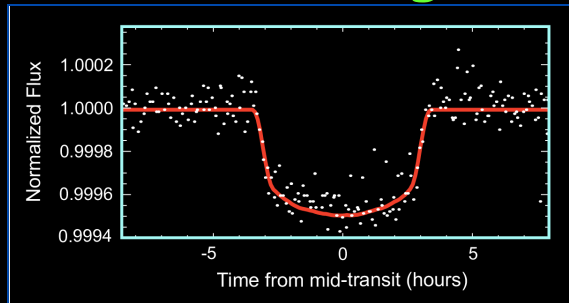
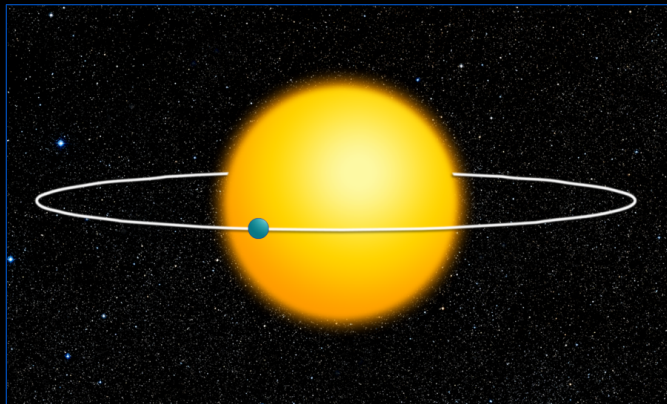
AAS 221st MEETING

Chris Burke:
216.02

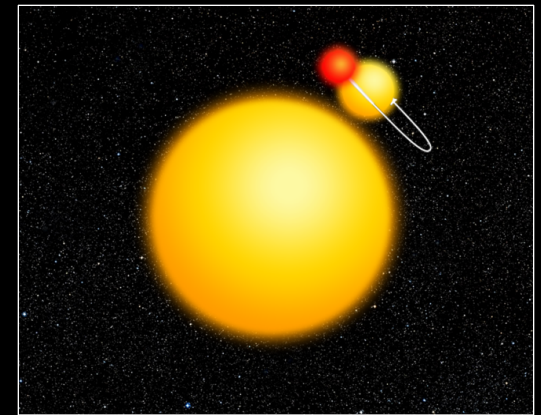
Kepler candidates PURITY : The issue of false positives

An observed periodic transit signal could be due to:

Transiting Planet



Eclipsing Binary Stars



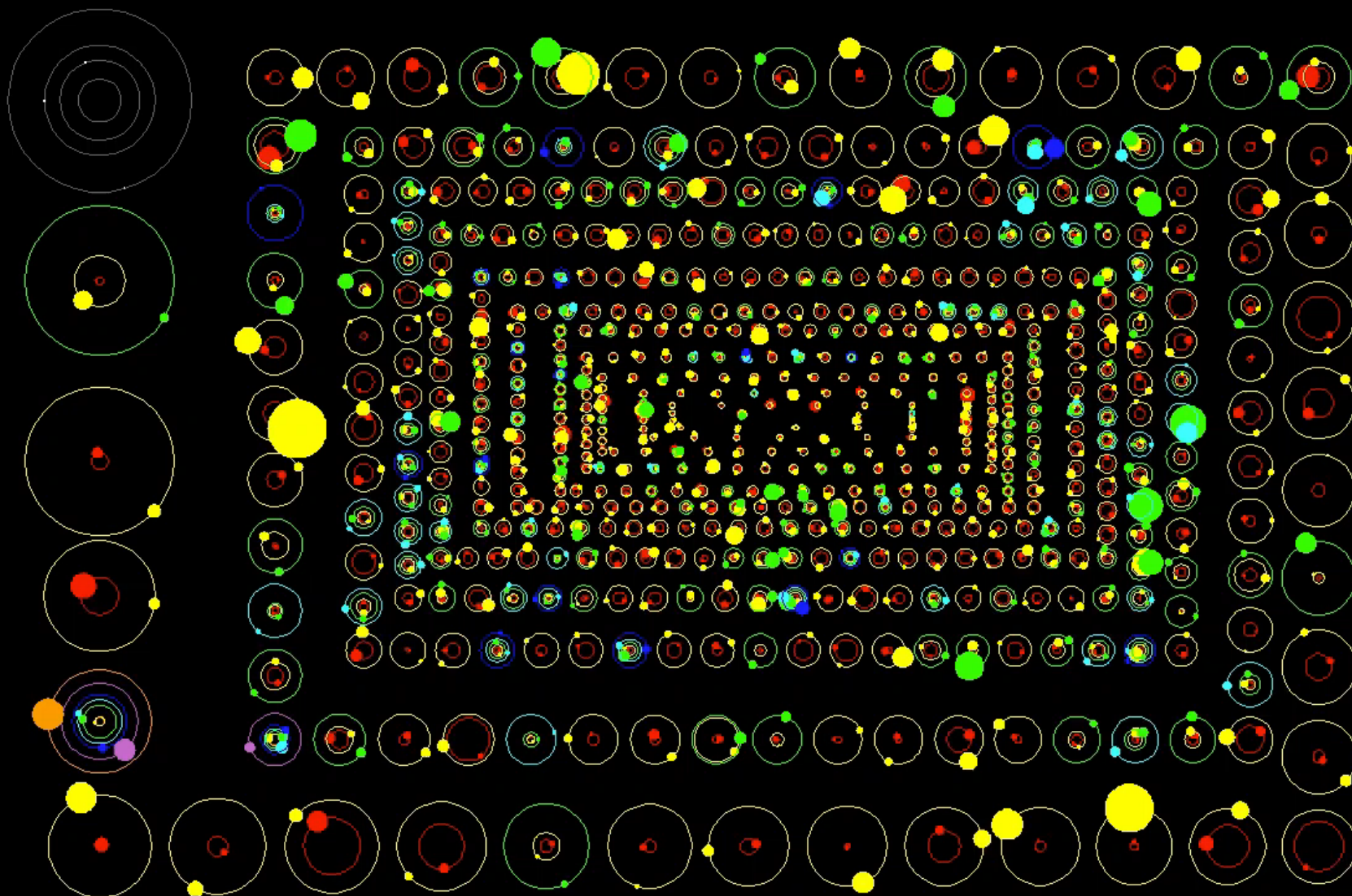
They found that eclipsing binary stars can only account for **9.5 %** of the huge number of Kepler candidates

Kepler has found planets smaller than Mercury!



The Kepler Orrery III

$t[\text{BJD}] = 2455215$

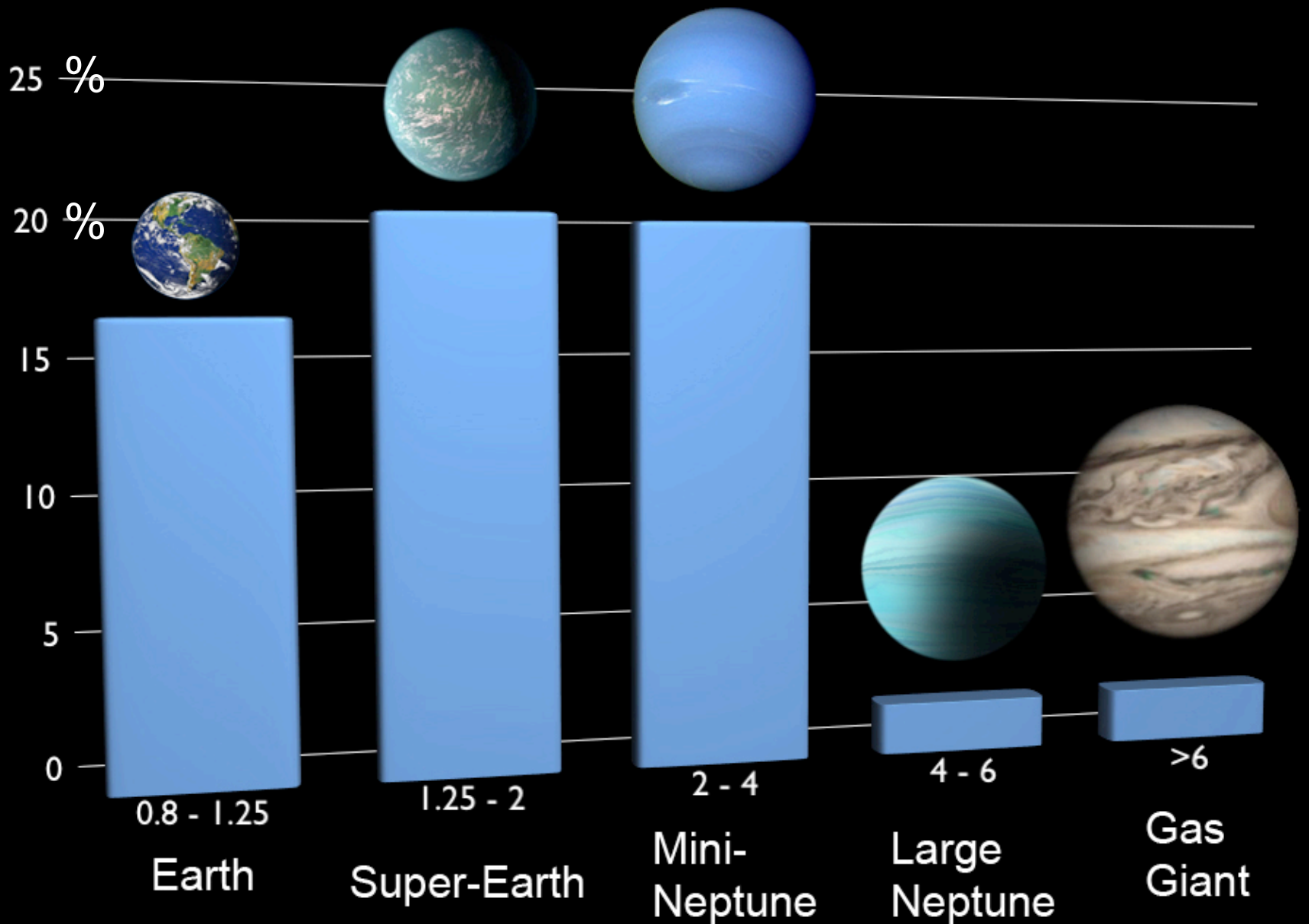


Discovery of first planets orbiting Binary Stars ... a “Tatooine”



Artists conception of
Kepler 16b

FRACTION OF STARS
WITH AT LEAST ONE PLANET



PLANET SIZE (relative to Earth)

Planets are VERY COMMON!

17 % stars have an
Earth-size planet within 85 days

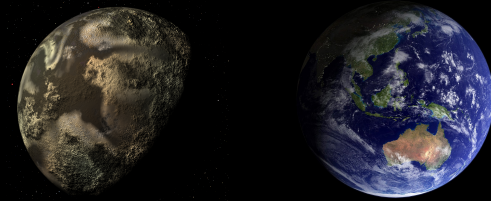
And 70 % within 400 days
But it does not include long-period
Earths & Super Earths



Almost all Sun-like stars have a planetary system !

Kepler Results ... so far...

At least 1 star in 6 has an Earth-size planet



Too early to tell
how many in HZ

Almost all stars have a planetary system



Small planets are equally common around all stars

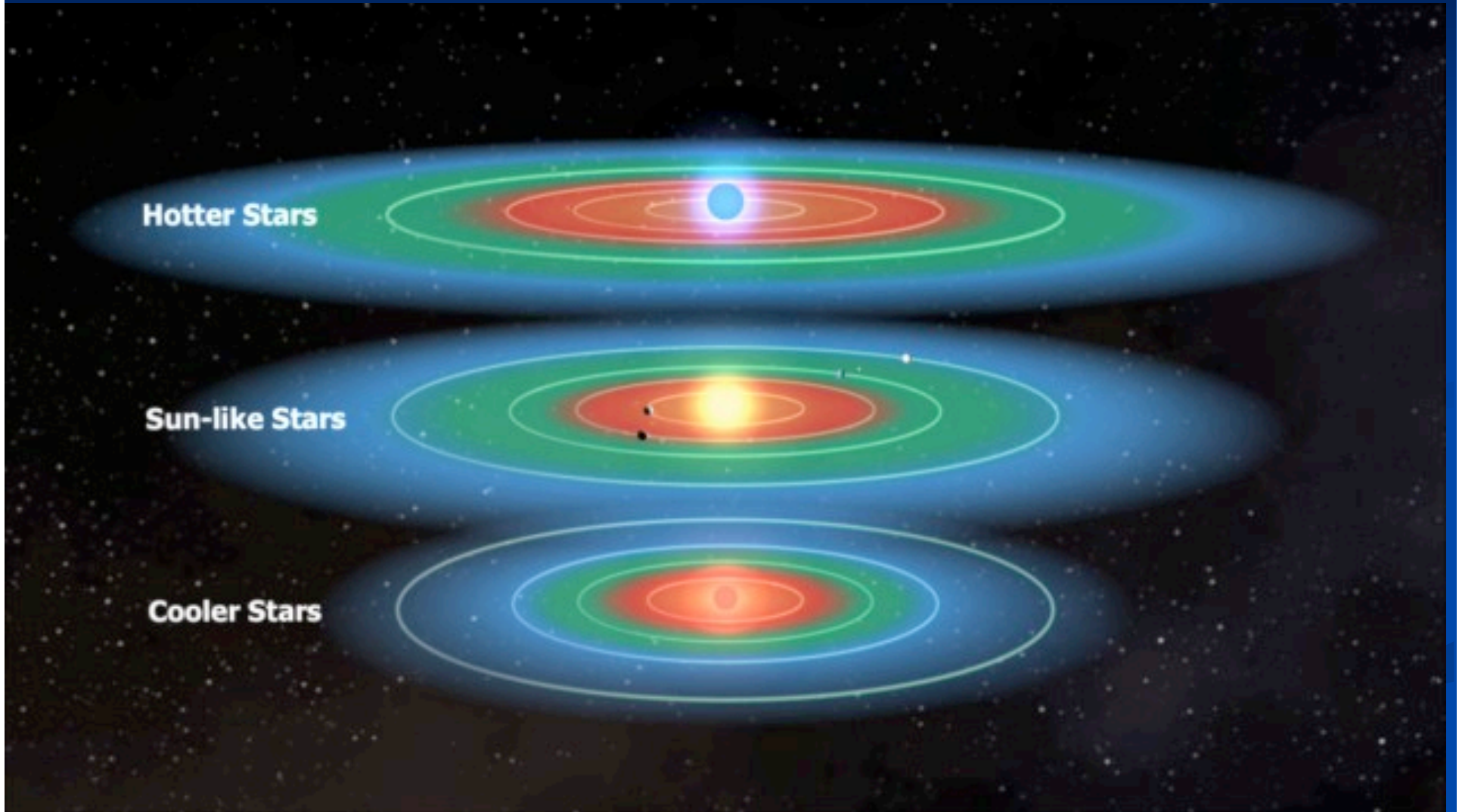


Size of Habitable Zone

Hotter Stars

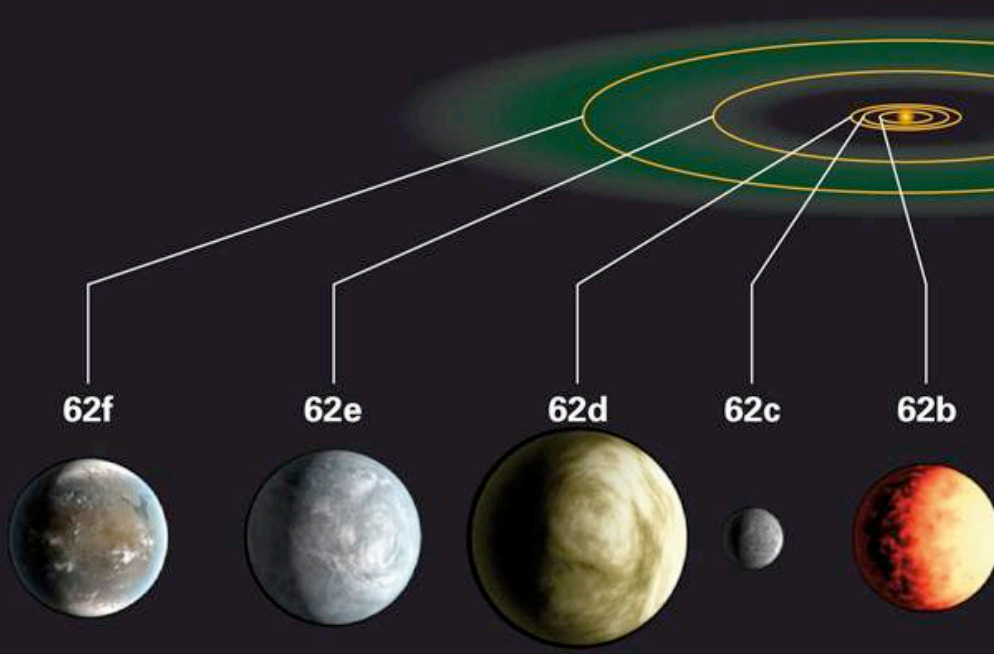
Sun-like Stars

Cooler Stars



Kepler-62-System

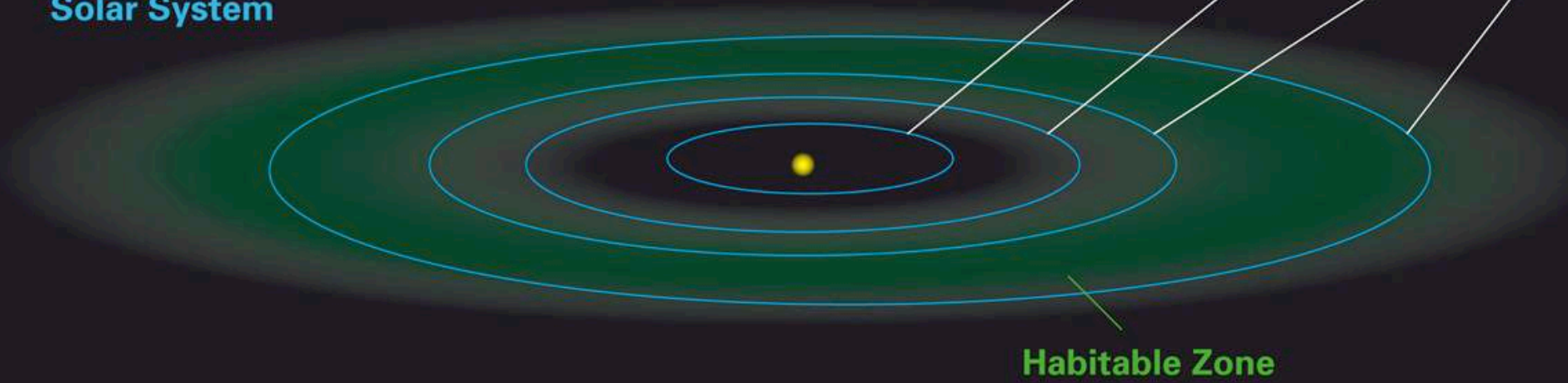
Habitable Zone



Mercury Venus Earth Mars

Solar System

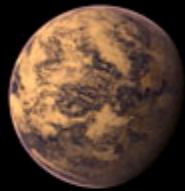
Habitable Zone



Potentially Habitable Exoplanets



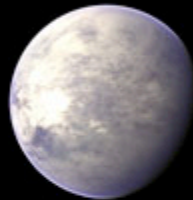
Earth



Gliese 667C c



Kepler-62 e



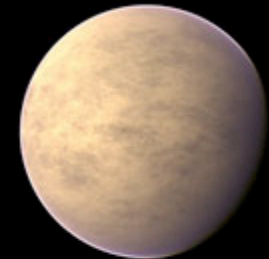
Tau Ceti e*



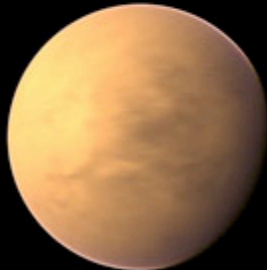
Gliese 581 g*



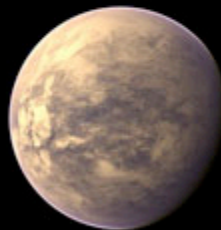
Gliese 667C f



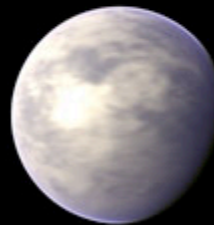
HD 40307 g



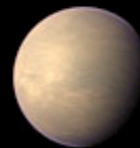
Gliese 163 c



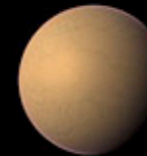
Kepler-61 b



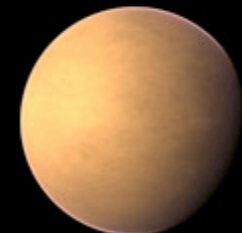
Kepler-22 b



Kepler-62 f



Gliese 667C e

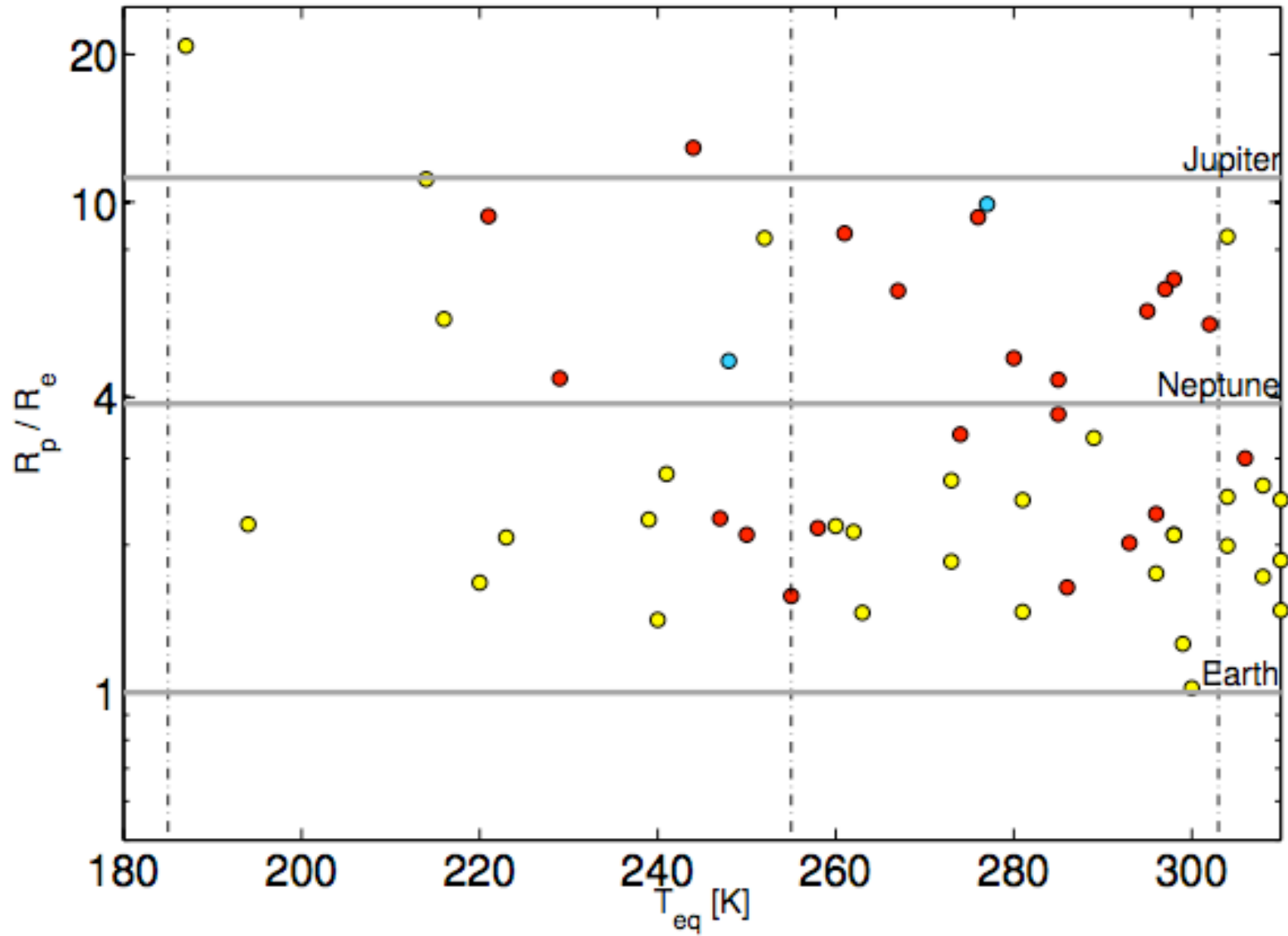


Gliese 581 d

*planet candidates

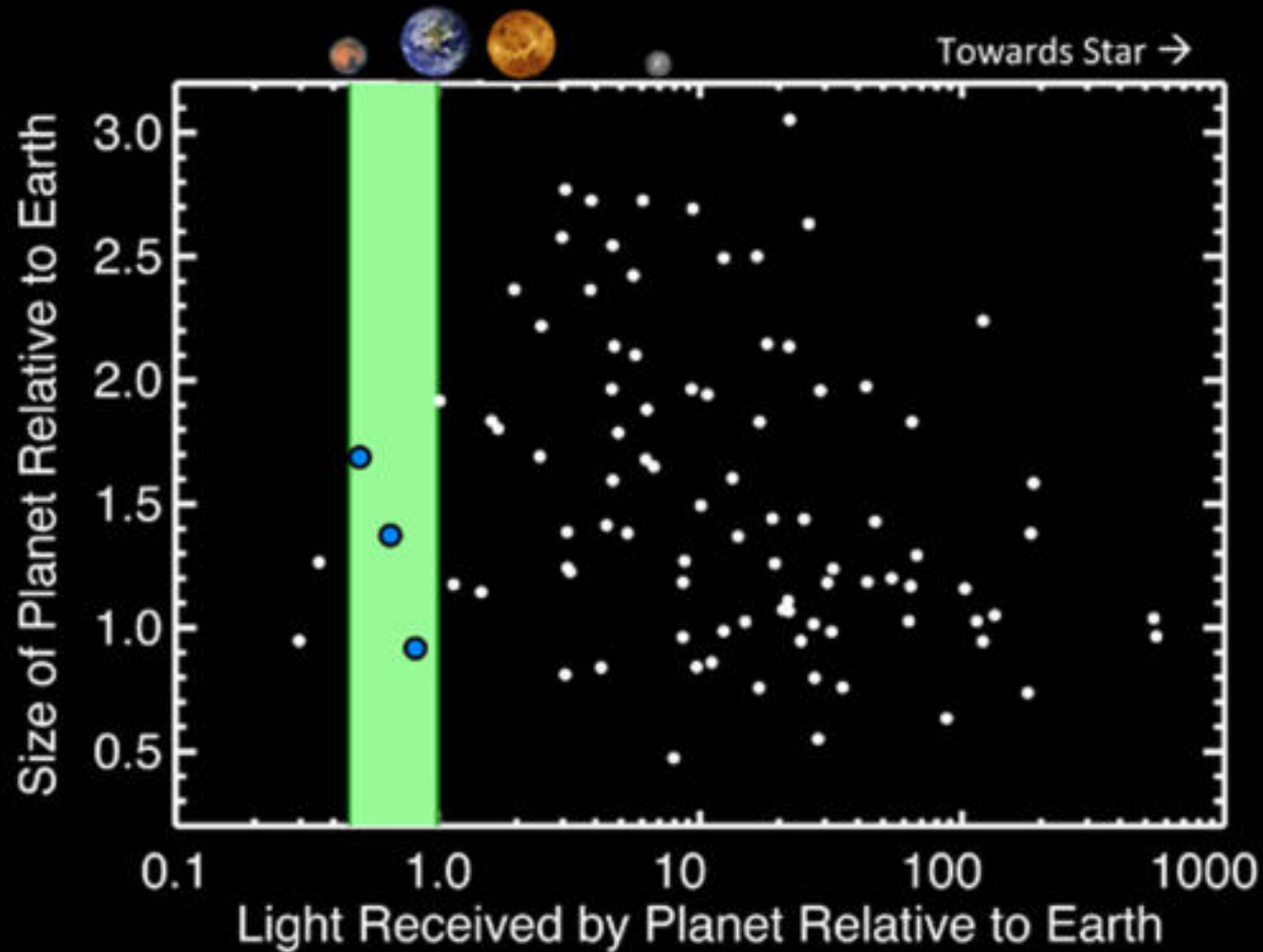
CREDIT: PHL @ UPR Arcibo (phl.upr.edu) December 5, 2013

Kepler candidates in Habitable Zone



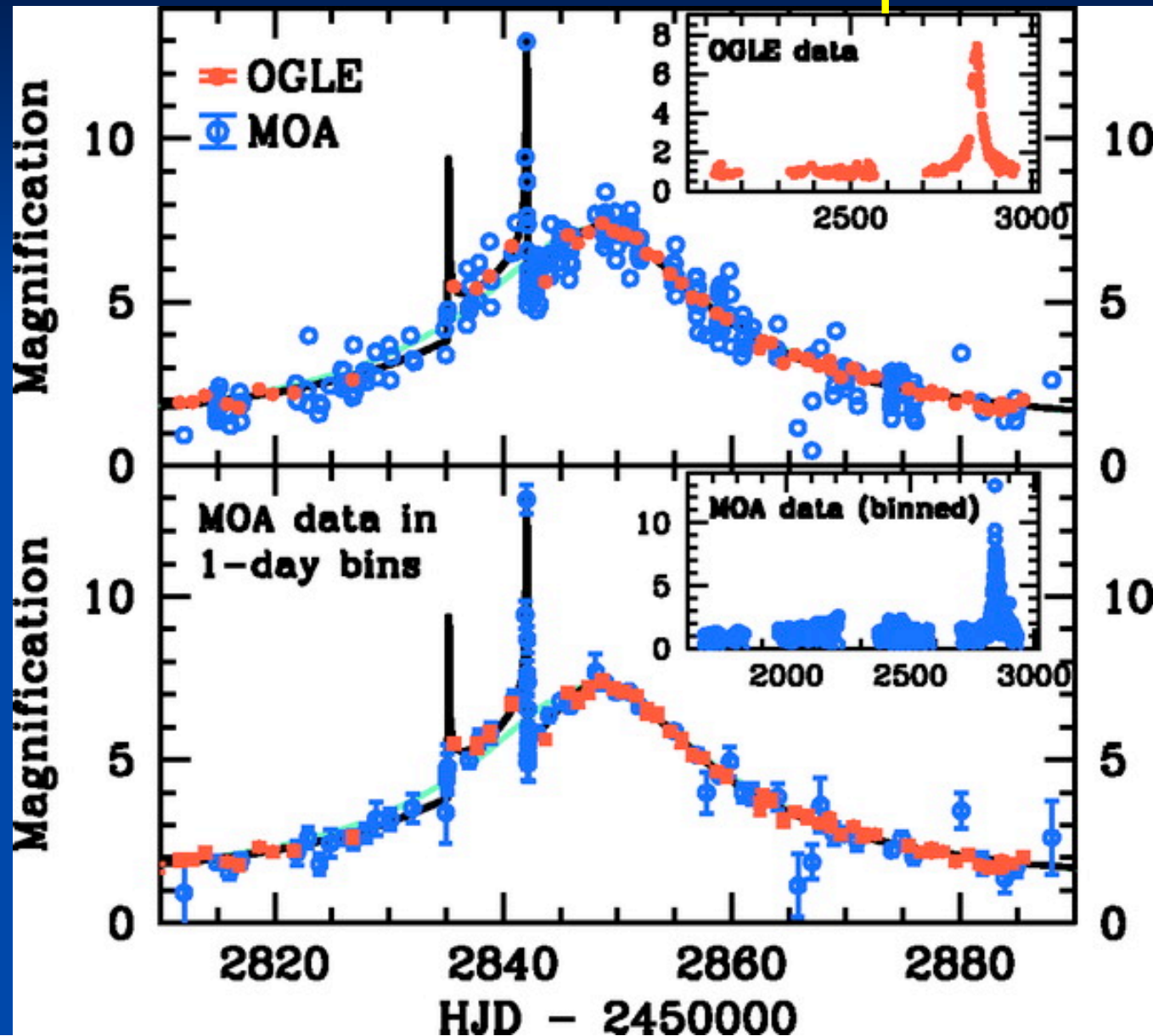
Earthlike Planets Around Dwarf Stars

95 Planet Candidates Orbiting Red Dwarfs



Microlensing - OGLE

Optical Gravitational Lens Experiment



Known Exoplanets as of March 4, 2014

- **1078 *confirmed* exoplanets**
 - RV/astrometry : 550 planets in 413 systems
(96 multiple sys.)
 - Transits: 438 planets in 333 systems
 - Microlensing: 27 planets in 25 systems
 - Direct Imaging: 47 planets in 43 systems

<http://exoplanet.eu/catalog.php>

Pace of Discovery

