ExoClock

Atelier ExoClock France

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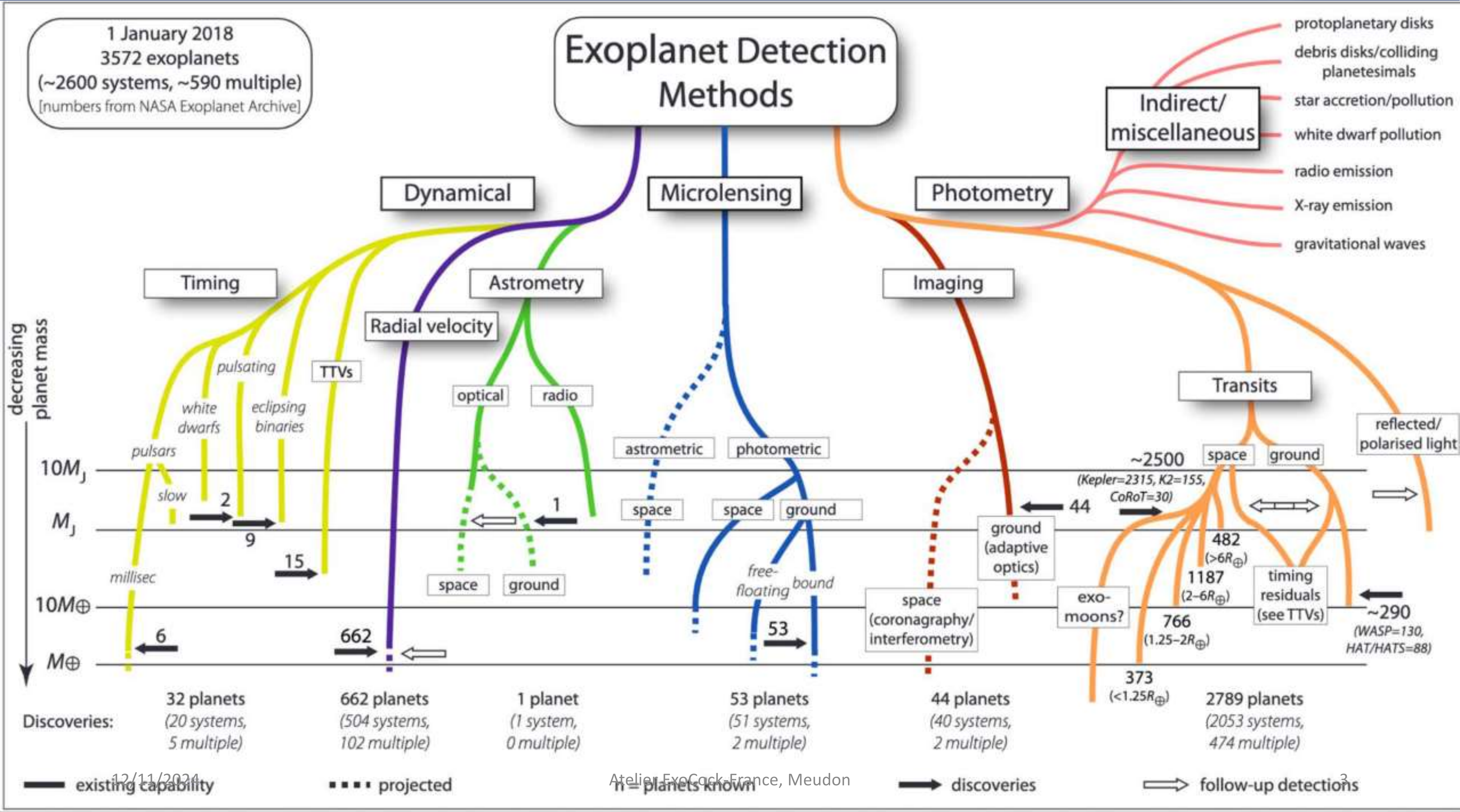
Avec l'aimable contribution de JP Beaulieu (IAP)

Meudon, 12 novembre 2024

Situation sur les observations d’exoplanètes



1 January 2018
3572 exoplanets
(~2600 systems, ~590 multiple)
[numbers from NASA Exoplanet Archive]
Exoplanet Detection Methods
Dynamical
Microlensing
Photometry
Indirect/ miscellaneous
protoplanetary disks
debris disks/colliding planetesimals
star accretion/pollution
white dwarf pollution
radio emission
X-ray emission
gravitational waves
Timing
Astrometry
Radial velocity
Imaging
Transits
decreasing planet mass
pulsating
white dwarfs
eclipsing binaries
TTVs
pulsars
slow
millisec
optical
radio
astrometric
photometric
space
ground
free-floating
bound
space (coronagraphy/ interferometry)
ground (adaptive optics)
exo-moons?
timing residuals (see TTVs)
reflected/ polarised light
$10M_J$
M_J
$10M_\oplus$
$M_\oplus$
2
9
15
6
662
1
53
44
~2500
(Kepler=2315, K2=155, CoRoT=30)
482 ($>6R_\oplus$)
1187 ($2–6R_\oplus$)
766 ($1.25–2R_\oplus$)
373 ($<1.25R_\oplus$)
~290
(WASP=130, HAT/HATS=88)
Discoveries:
32 planets (20 systems, 5 multiple)
662 planets (504 systems, 102 multiple)
1 planet (1 system, 0 multiple)
53 planets (51 systems, 2 multiple)
44 planets (40 systems, 2 multiple)
2789 planets (2053 systems, 474 multiple)
existing capability
projected
n = planets known
discoveries
follow-up detections

About composition and density

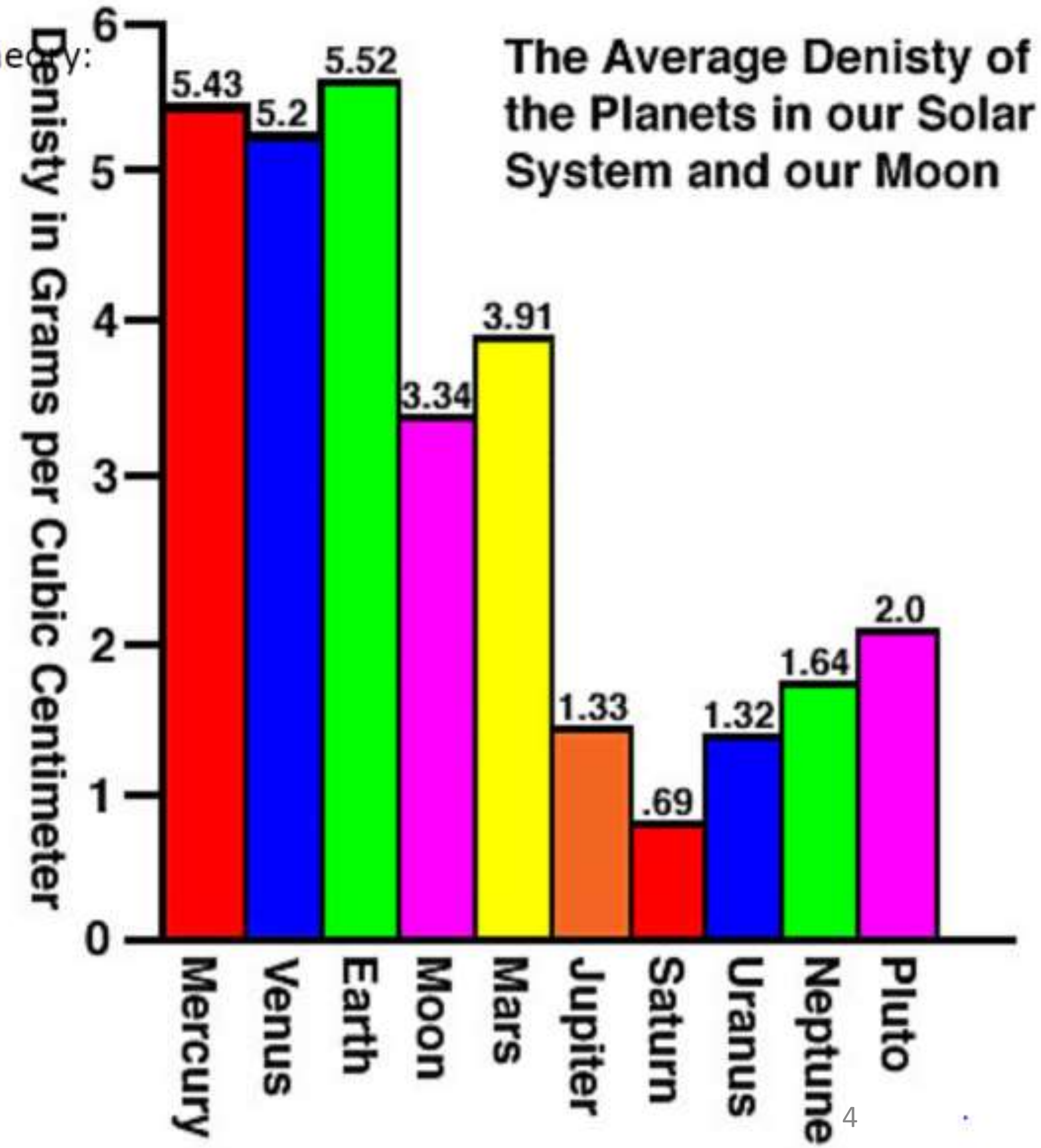
- Densities and distances of objects in solar system supports this condensation theory:

  - Rocky planets : 3-6 *g cm*$^{-3}$
    => mostly rocks and metals.

  - Gazeous planets: 1-2 *g cm*$^{-3}$
    => Rocky-core, ices and gazes

  - Inner belt asteroids: contains metals and rocks

  - Outer main belt, KBOs: less metals, more ices



DETECTION DE PLANETES EXTRASOLAIRES

6 octobre 2023:

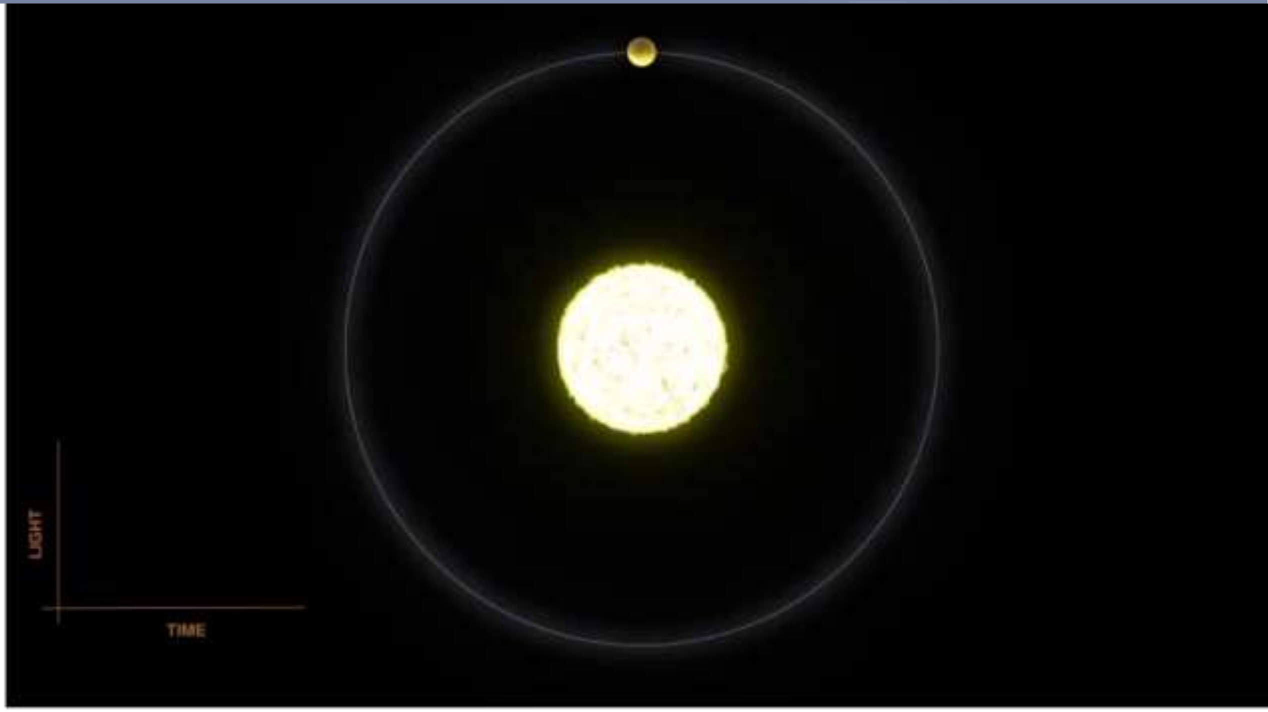
5506 planètes,
4064 systèmes planétaires,
878 planètes multiples

- Astrométrie : 20 planets / 9 planetary systems
- Vitesses radiales : 1073 planets / 802 planetary systems / 184 multiple
- Transit : 3809 planets / 2881 planetary systems / 602 multiple
- Lentilles gravitationnelles : 263 planets / 241 systems / 10 multiple
- Imagerie directe : 233 planets / 138 planetary systems / 8 multiple

The transit technique

Only planets closed to ~ 90 deg inclinaison

Transit probability $\mathcal{P}_{tr} = \frac{R_* + R_p}{a(1-e^2)} \simeq R_*/a$

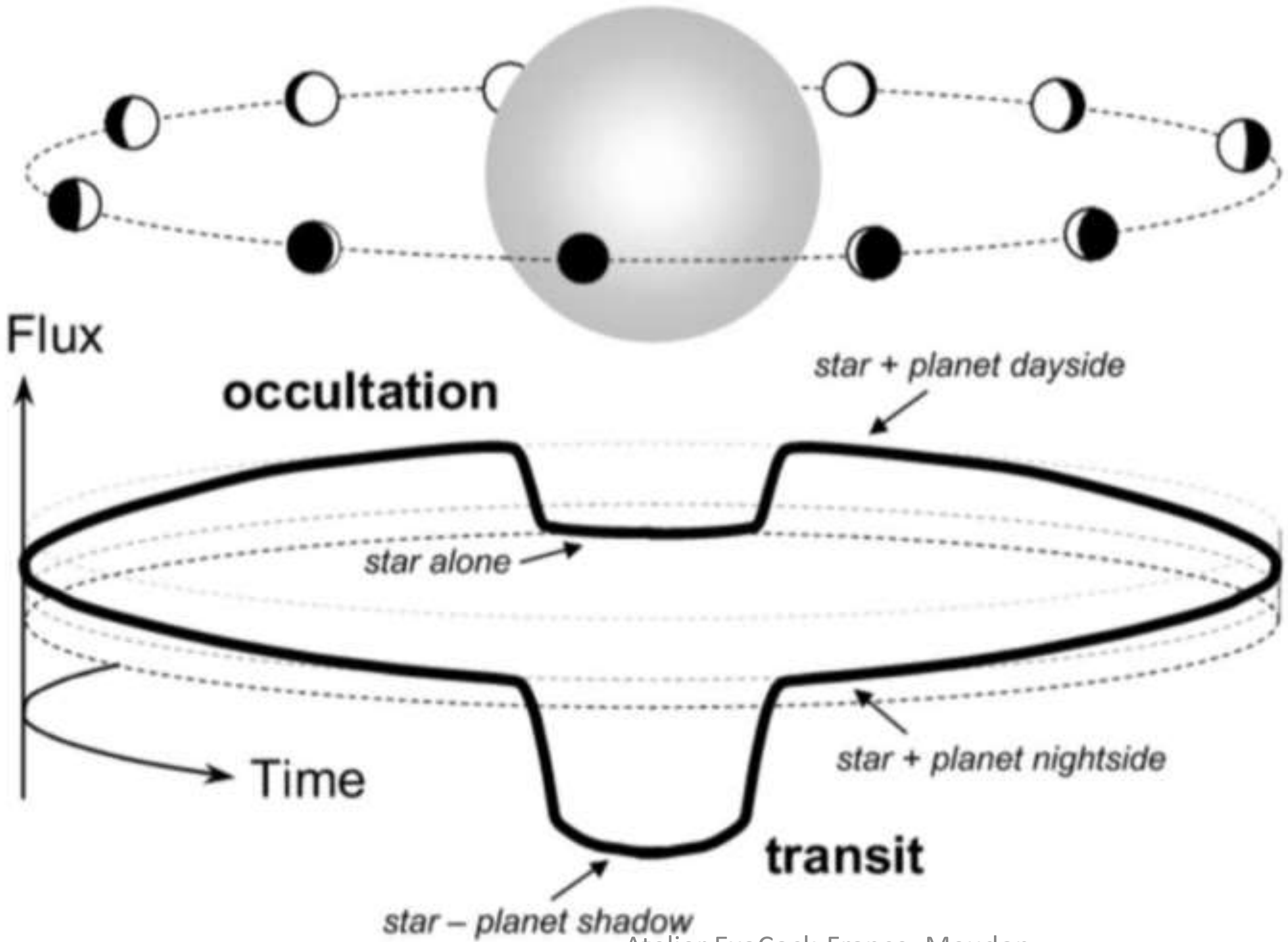


10 % probability for a planet at 0.05 AU around a solar like star

Transit depth $\Delta F/F \simeq R_p^2/R_*^2$

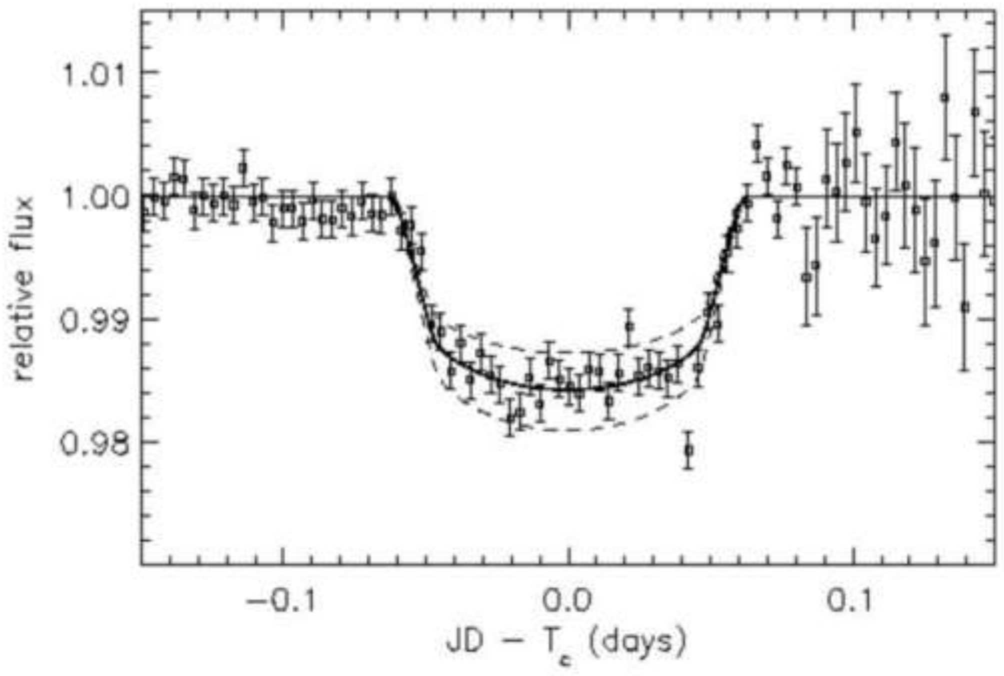
Jupiter : 1 % depth Earth: 0.01 % depth

transit and occultations



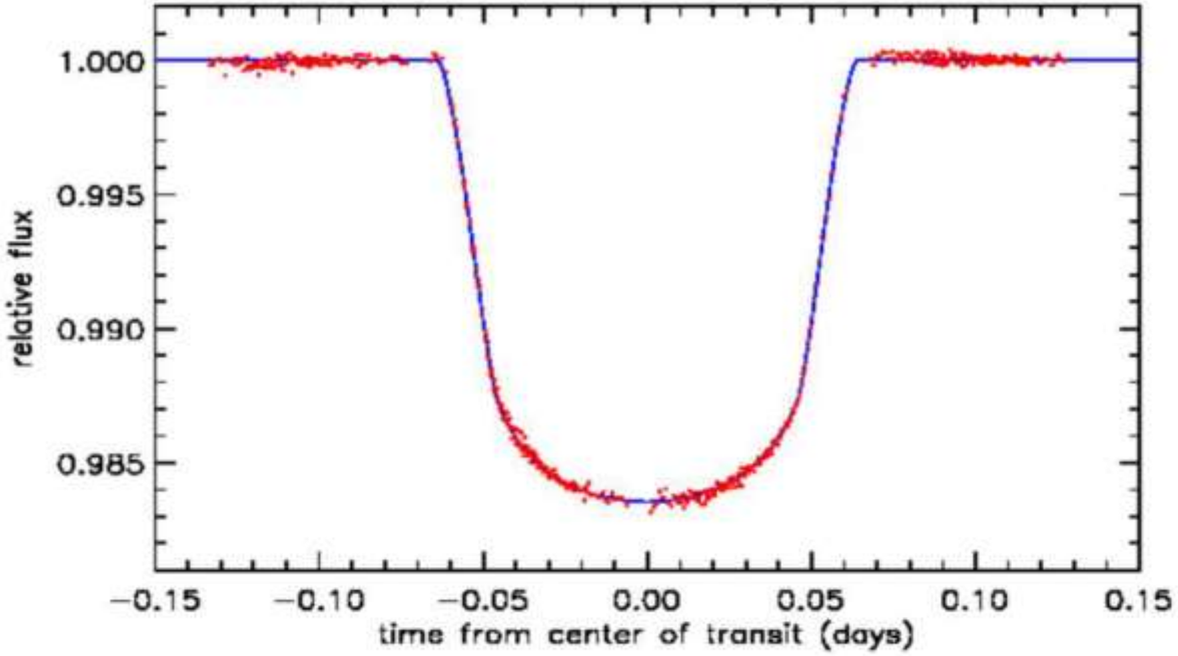
HD209458b transiting hot Jupiter in 1999

Observations du sol



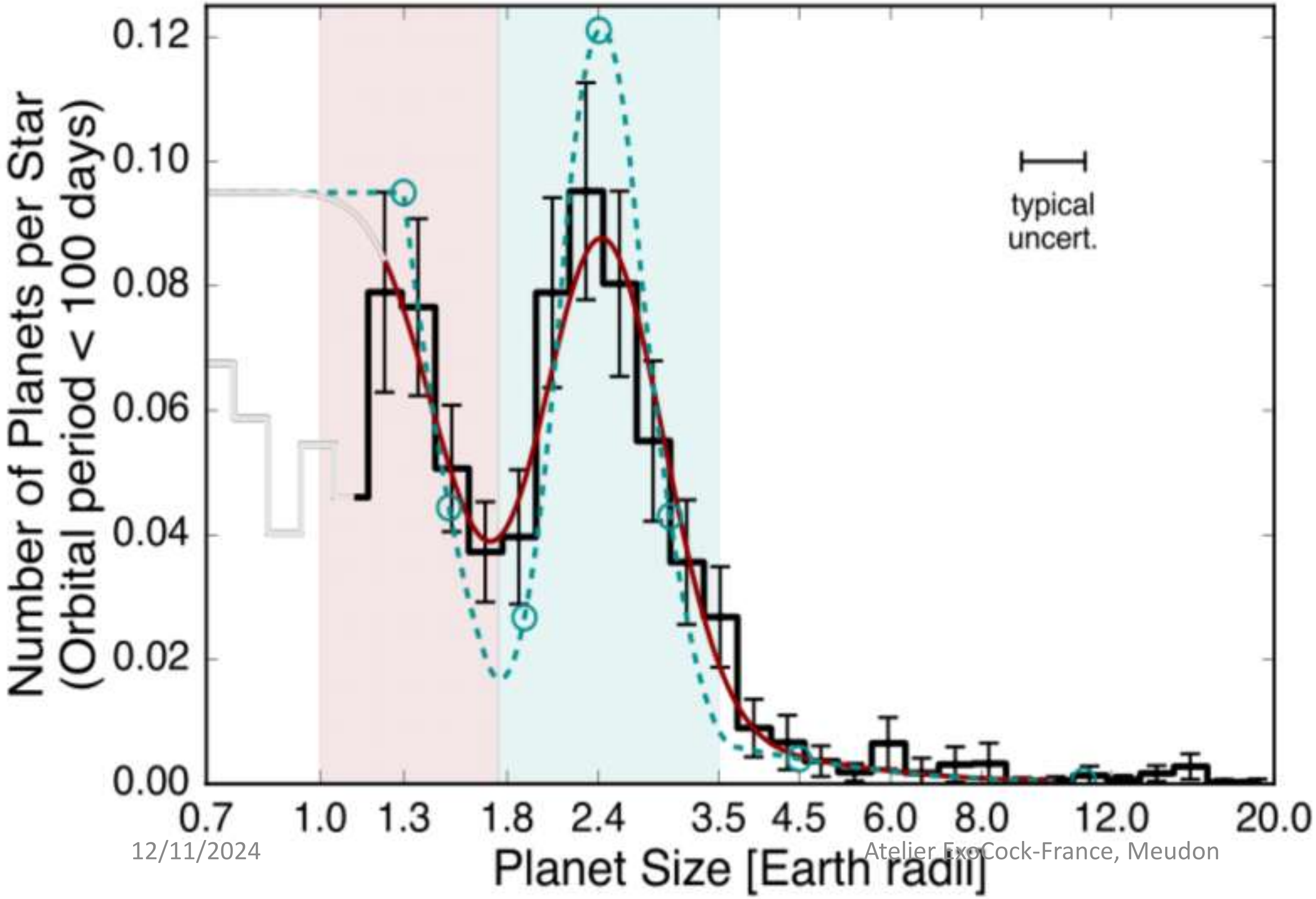
Charbonneau et al. (1999)

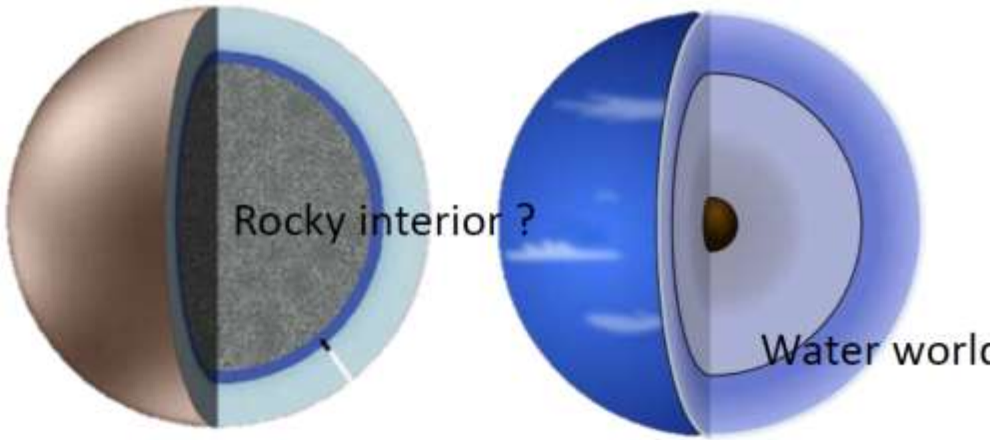
Observations spatiale HST



Charbonneau et al. (2000)

Histogram of planet radii, 2 peaks, super-Earth and Mini-Neptune

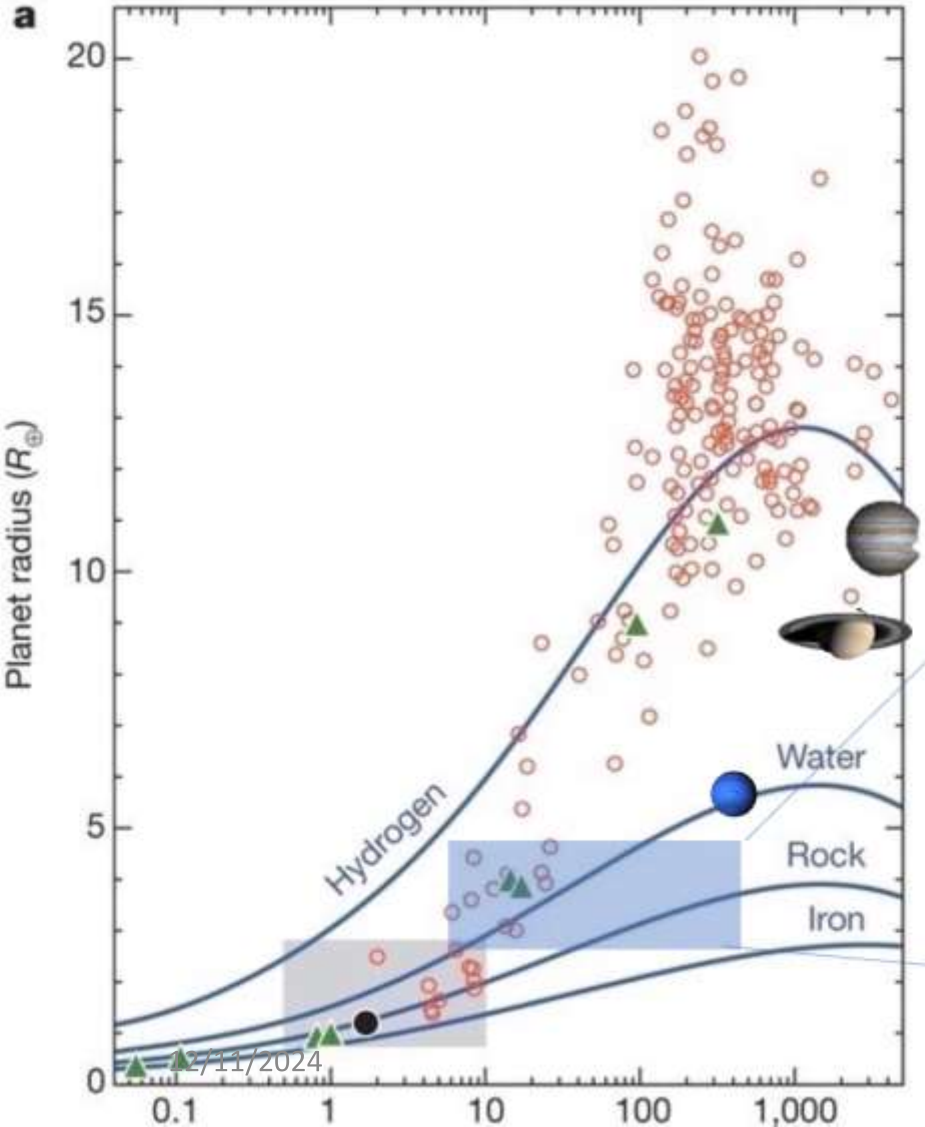


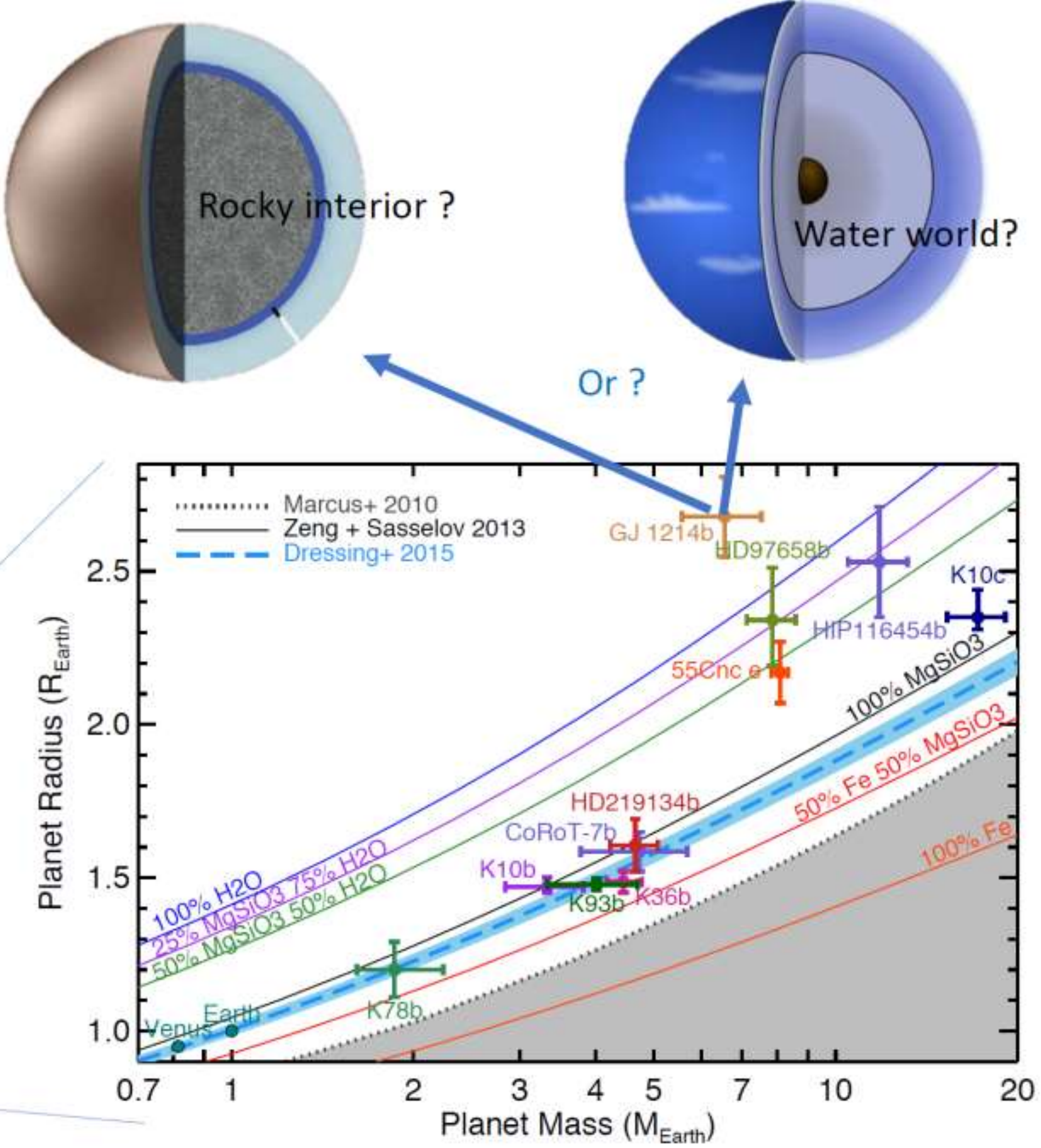


Completeness-corrected histogram of planet radii for planets with orbital periods shorter than 100 days.

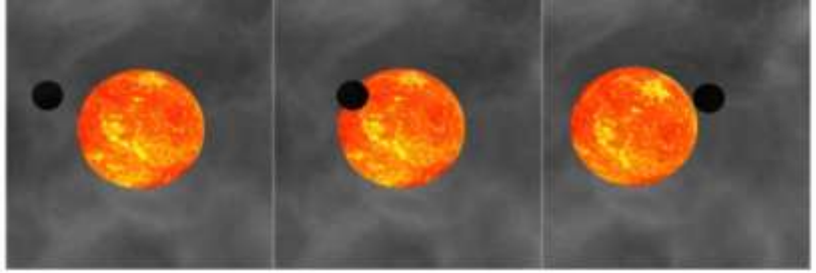
Lightly shaded regions encompass our definitions of "super-Earths" (light red) and "sub-Neptunes" (light cyan). The dashed cyan line is a plausible model for the underlying occurrence distribution after removing the smearing caused by uncertainties on the planet radii measurements.

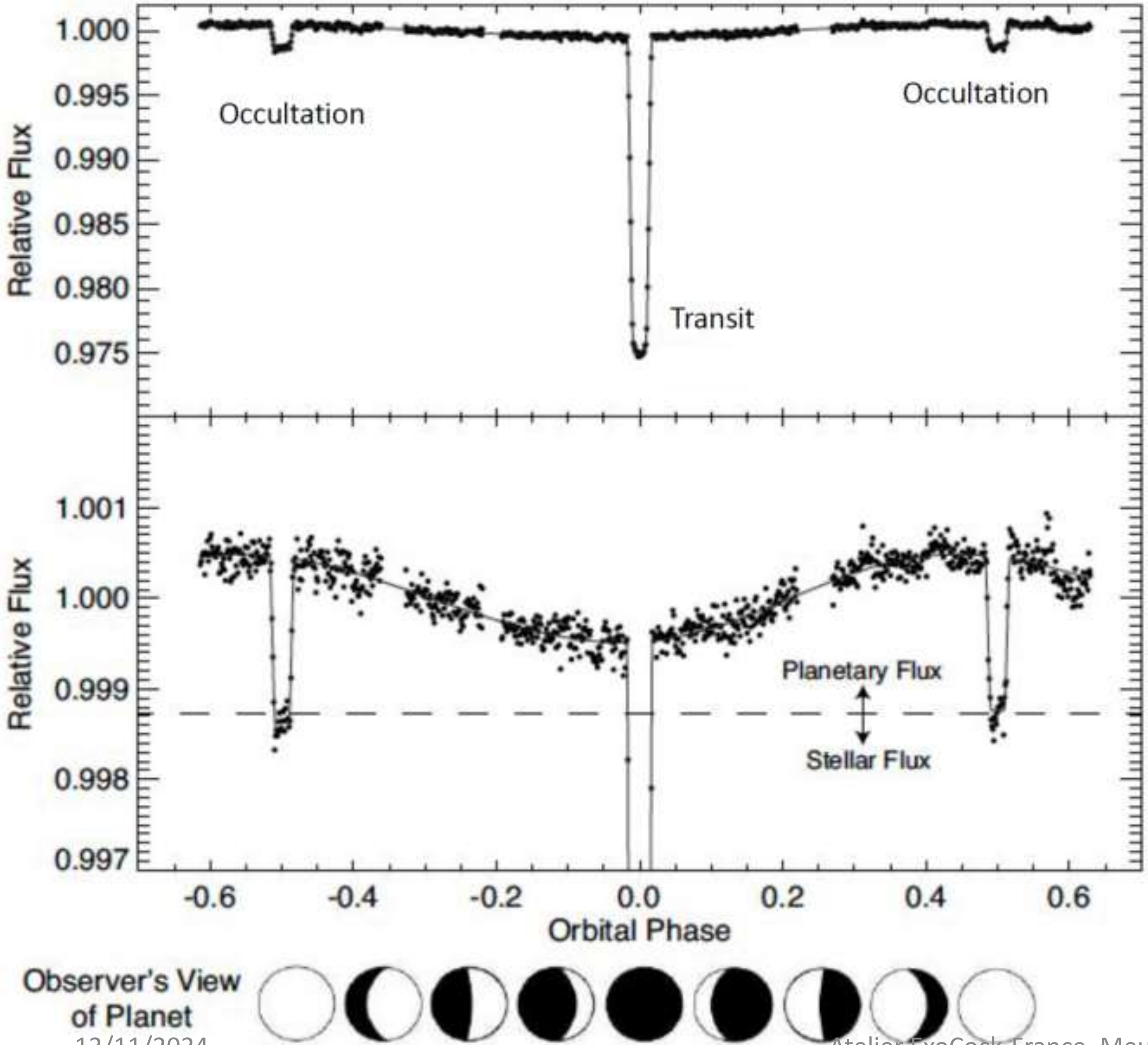
Classification according to density





Howard et al., 2013; Motalebi et al., 2015





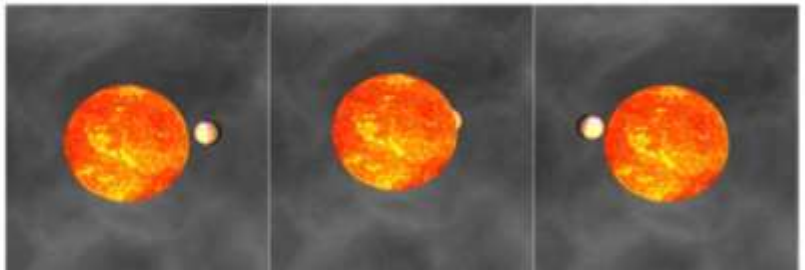
Transit depth:

$$\delta_{tra} = \left(\frac{R_p}{R_\star}\right)^2$$

Occultation depth:

$$\delta_{occ} = \frac{I_p}{I_\star}\left(\frac{R_p}{R_\star}\right)^2$$

Flux ratio day side of the planet / star



At different wavelength, because of different absorbing molecules-> different effective radius