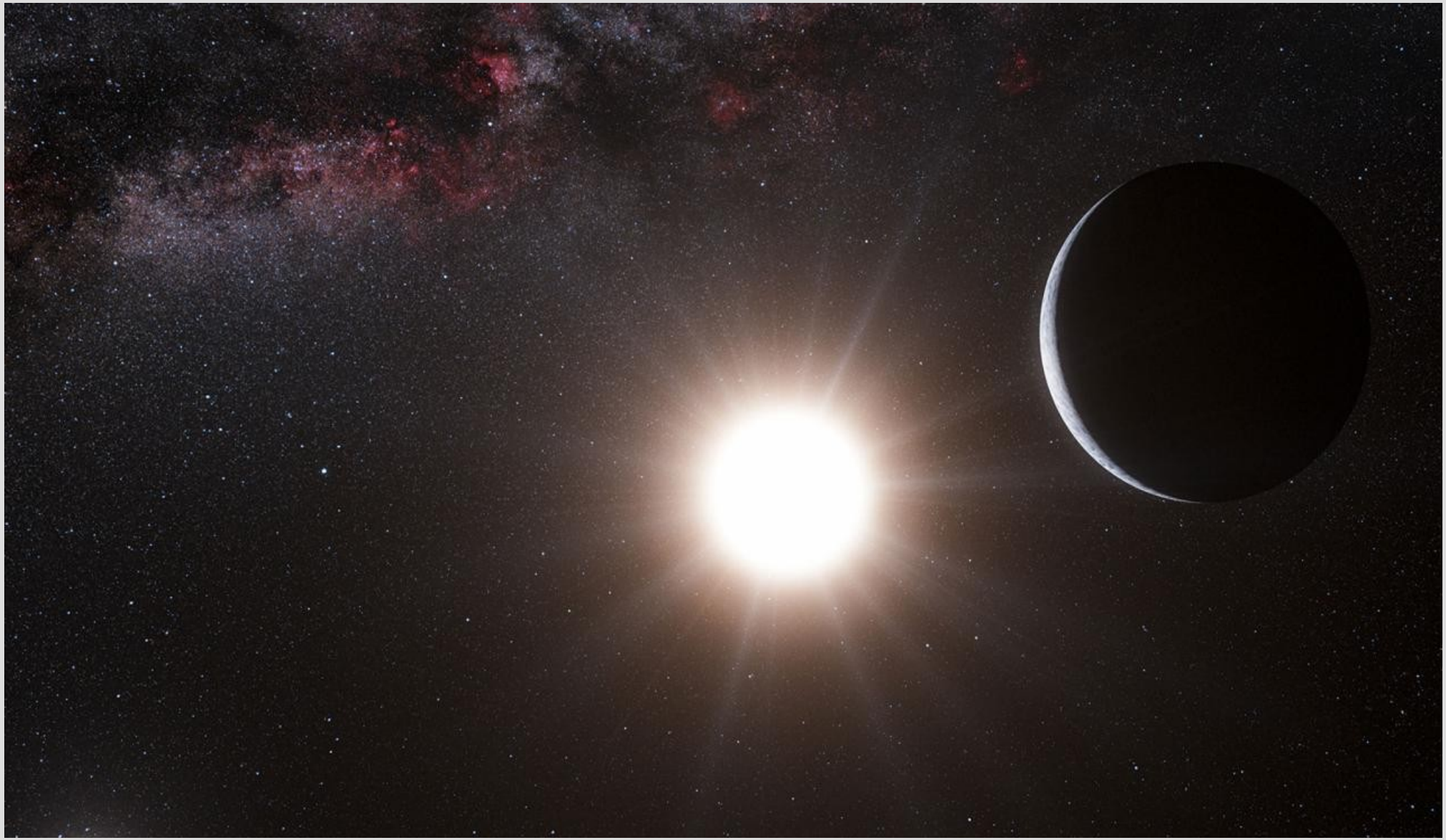
ASTR 407/507

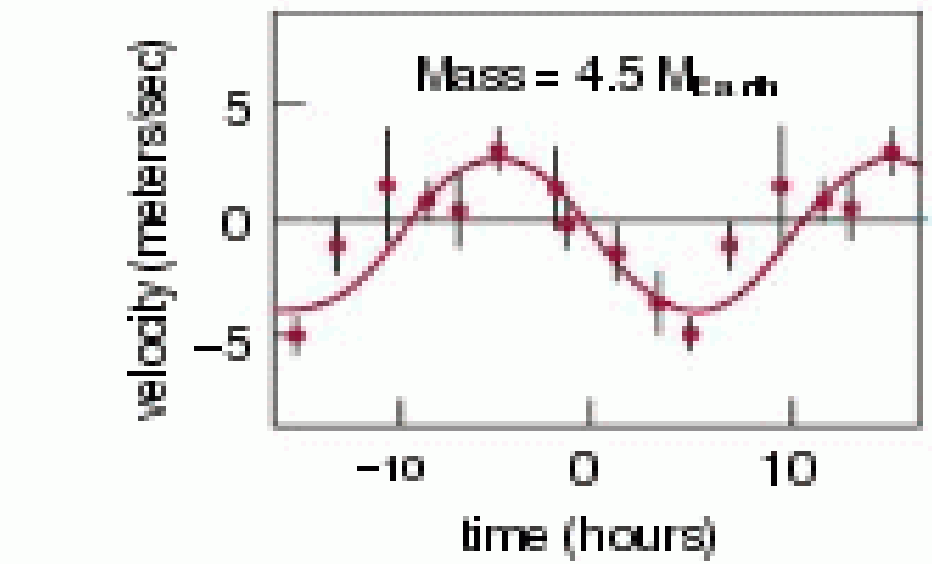
Properties of Extrasolar planets

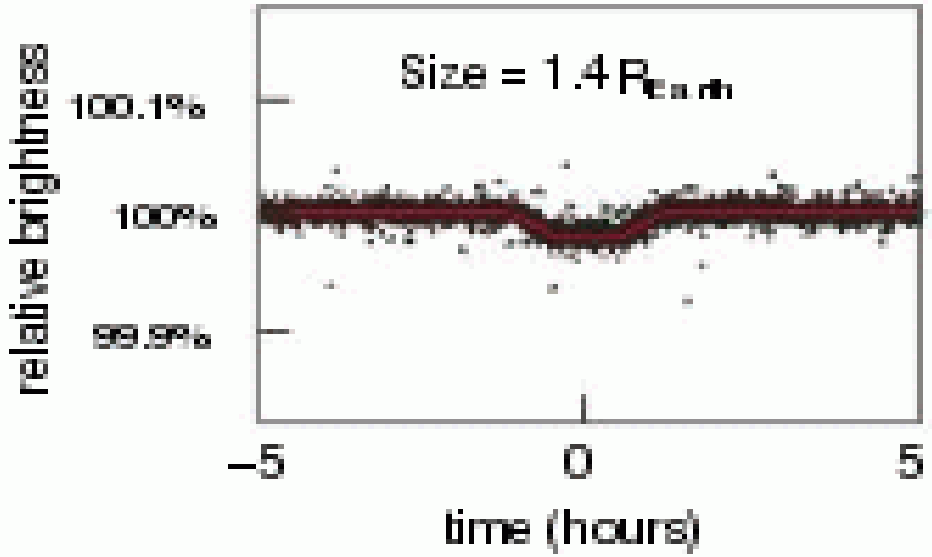


What kind of physical properties might be accessible?

- Obviously we would like to know things like
  - Mass
  - Radius
  - Chemical composition
    - Bulk
    - Upper atmosphere
  - Internal structure

IF you can combine RV and transit techniques





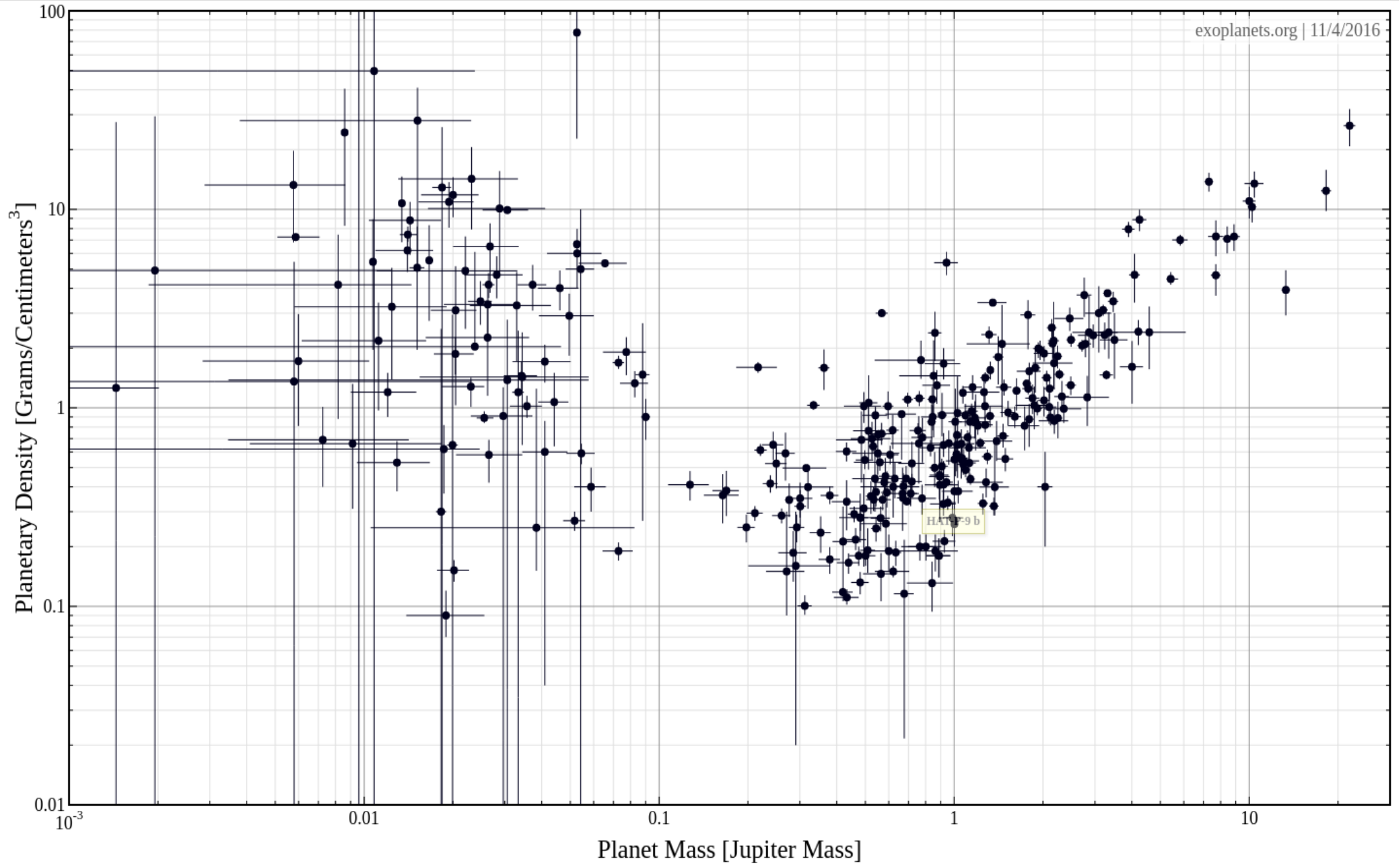
planet density:

$$\frac{\text{mass}}{\text{volume}} = 8.8\ \text{g/cm}^3$$

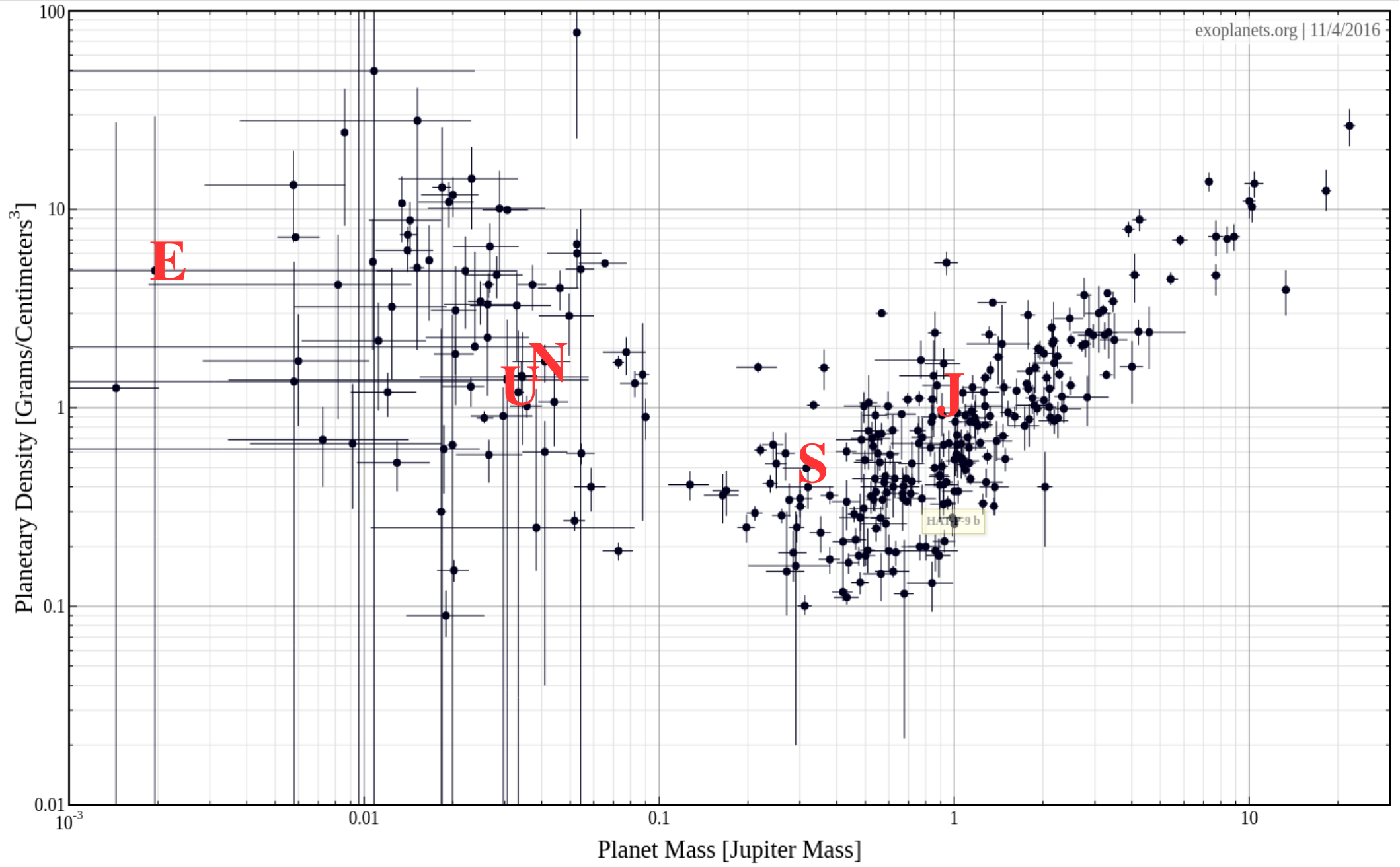
This is a rather extreme outlier... Density of iron!

There are also very low!

Currently known estimated masses and densities

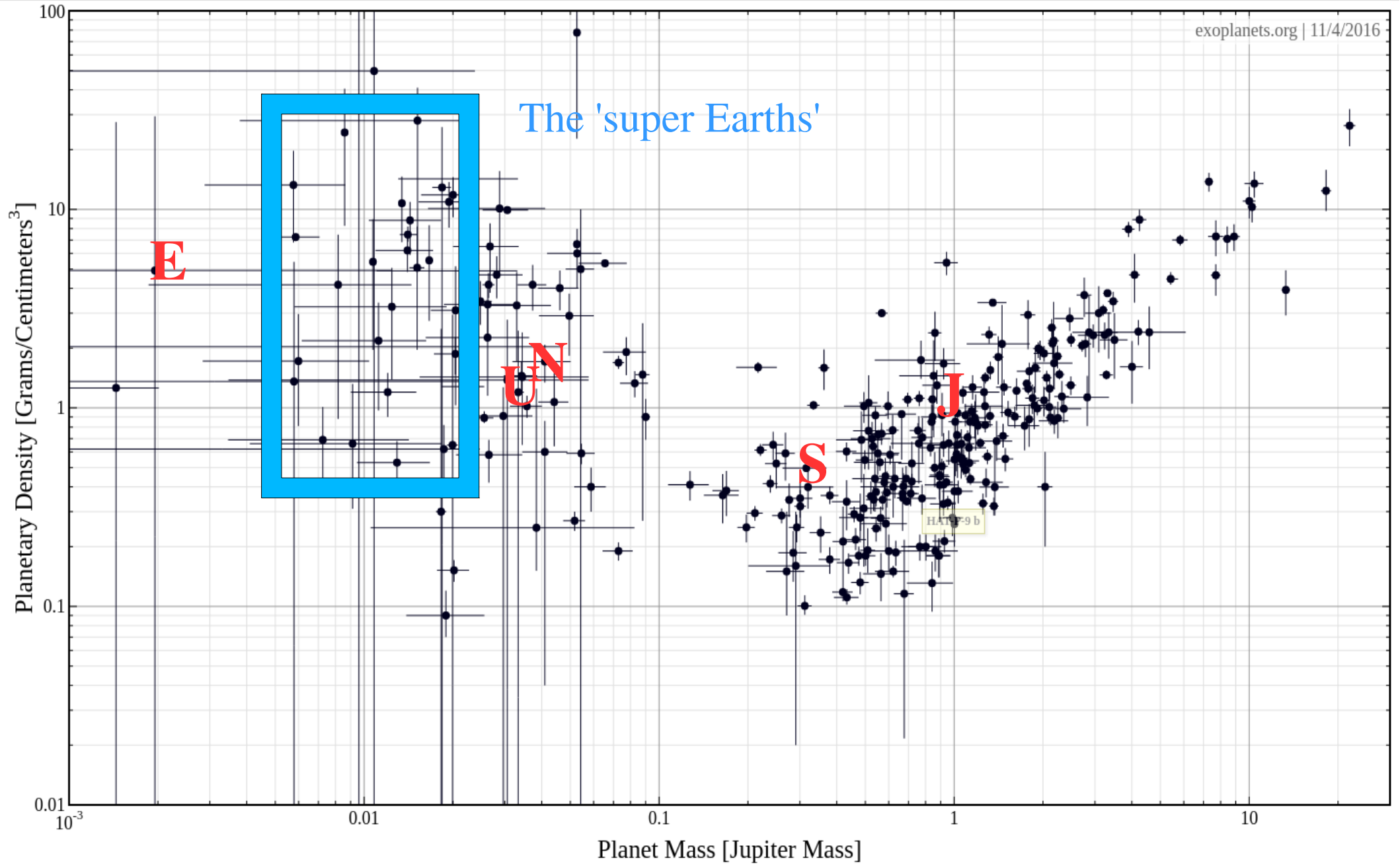


Currently known estimated masses and densities



Very similar to the values for Earth, Uranus, Neptune, Saturn, Jupiter

Currently known estimated masses and densities



Very similar to the values for Earth, Uranus, Neptune, Saturn, Jupiter

Mass-radius relationships

- Extract the best measurement, and find (for $R_P < 1.5\ R_E$)

$$\rho_P = 2.43 + 3.39 \left(\frac{R_P}{R_\oplus}\right) \mathrm{g\,cm^{-3}}.$$

  – Looks like expected self compression for silicate bodies

- For LARGER planets, a mass-radius relation is fit:

For exoplanets satisfying $1.5 \leq R_P/R_\oplus < 4$, we calculate an empirical fit to their masses and radii, yielding:

Weiss and Marcy (2013)

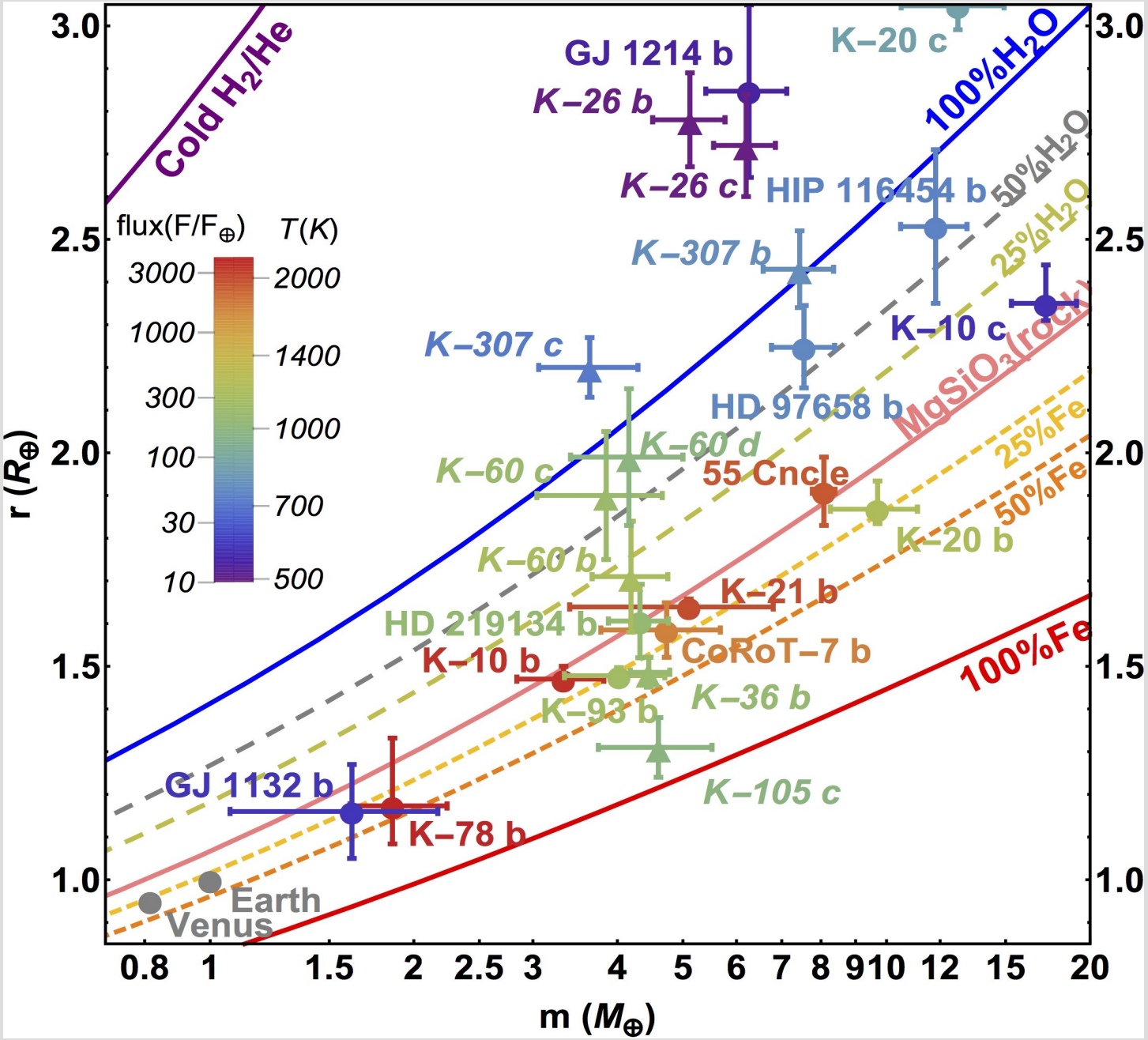
$$\frac{M_P}{M_\oplus} = 2.69 \left(\frac{R_P}{R_\oplus}\right)^{0.93} \quad (3)$$

with reduced $\chi^2 = 3.5$ and RMS=4.7 $M_\oplus$. We exclude Uranus and Neptune from this fit because they differ from the exoplanets in our sample. Most of the exoplanets in our sample have $P < 50$ days, and so we do not expect them to resemble Uranus and Neptune, which have orbital periods of tens of thousands of days.

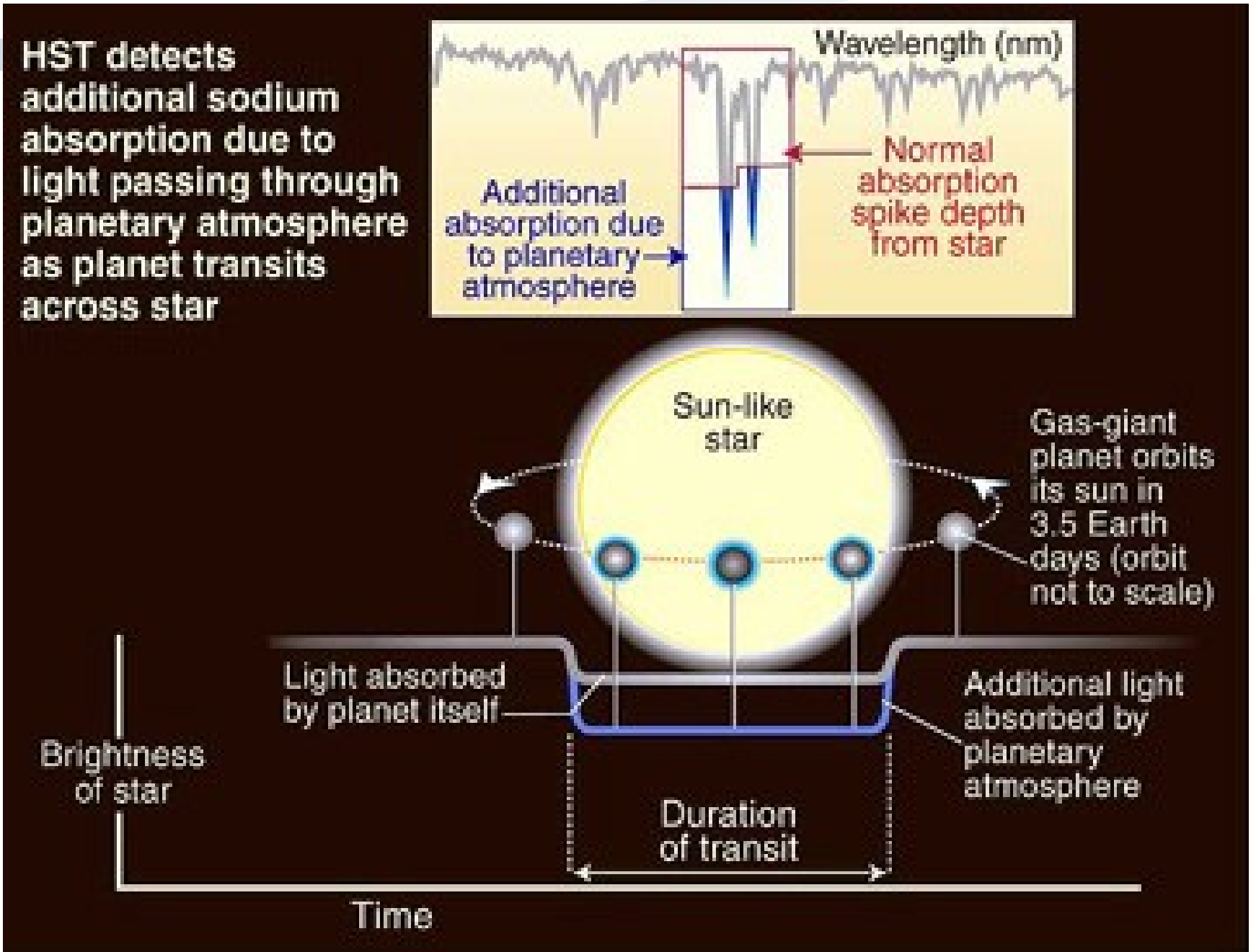
- For even larger planets (Uranus/Neptune scale) the mass-radius relation become quadratic in R

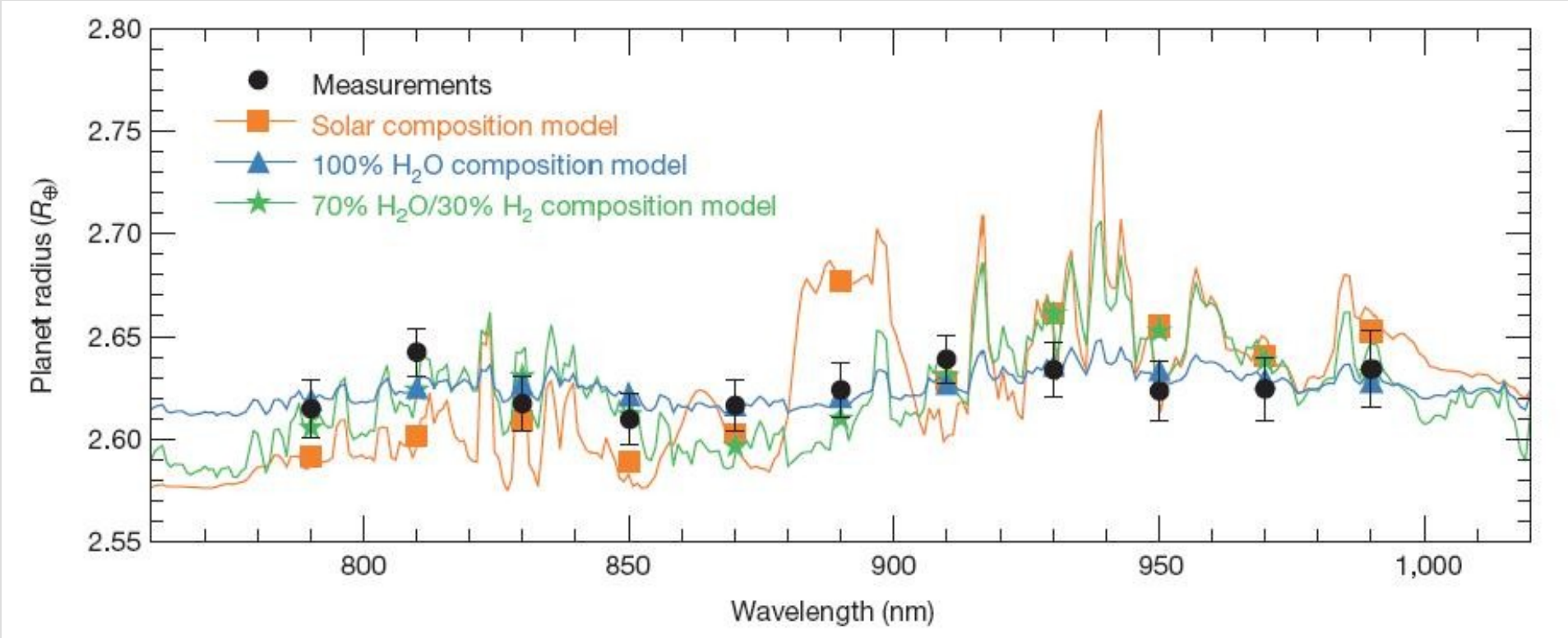
How are M and R related to bulk compostion?

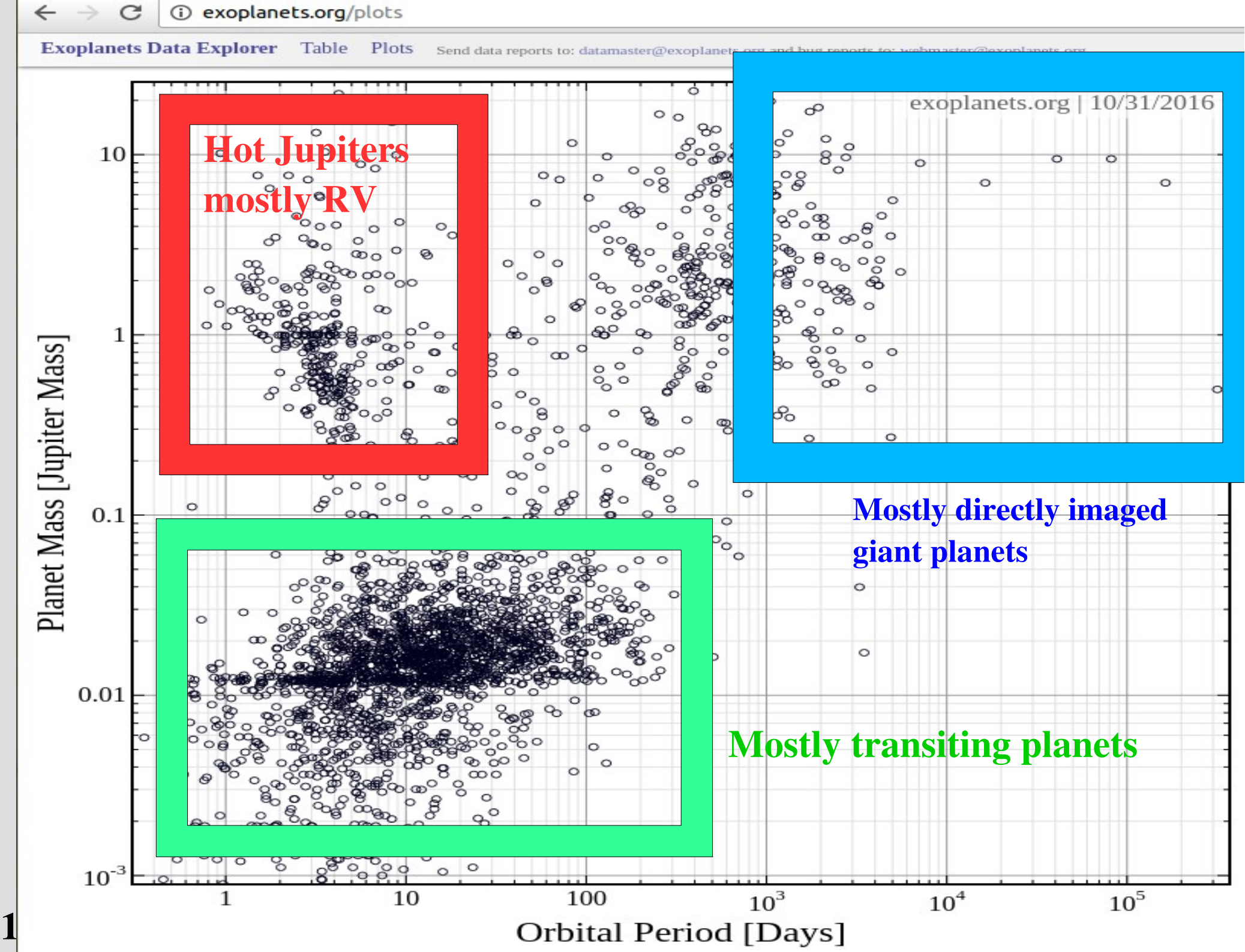
- **Models of the mass versus radisu**



Limited atmospheric composition available in transit spectroscopy




Measurements
Solar composition model
100% H_2O composition model
70% H_2O/30% H_2 composition model
Planet radius ($R_\oplus$)
2.80
2.75
2.70
2.65
2.60
2.55
800
850
900
950
1,000
Wavelength (nm)


exoplanets.org/plots
Exoplanets Data Explorer
Table
Plots
Send data reports to: datamaster@exoplanets.org and bug reports to: webmaster@exoplanets.org
Hot Jupiters
mostly RV
exoplanets.org | 10/31/2016
Mostly directly imaged
giant planets
Mostly transiting planets
Planet Mass [Jupiter Mass]
Orbital Period [Days]
10
1
0.1
0.01
10^{-3}
1
10
100
10^3
10^4
10^5

Directly imaged planets

- These are detected at great distances
  - Thus large orbital semimajor axes, with large orbital periods
- Too far away to have non-negligible chance of transiting star, and period would be decades or longer
  - Even orbital motion will require a long time to detect
- How can we get any information about the planet? We can measure only:
  - Separation from star
  - Since imaged, we can at least get the flux in the detection band, and sometimes others
  - No direct masses

Masses of imaged planets estimated via flux models of cooling planets