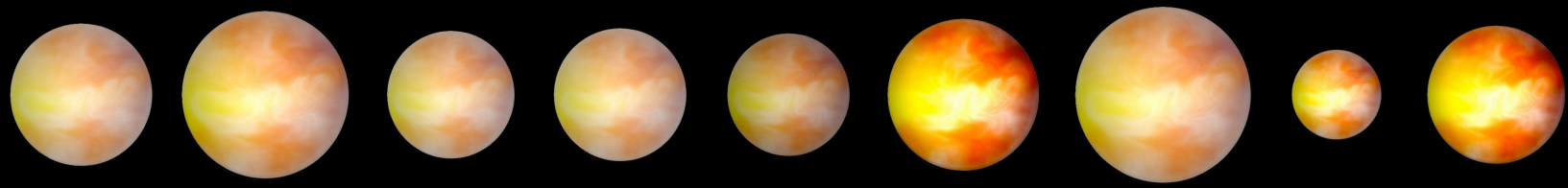
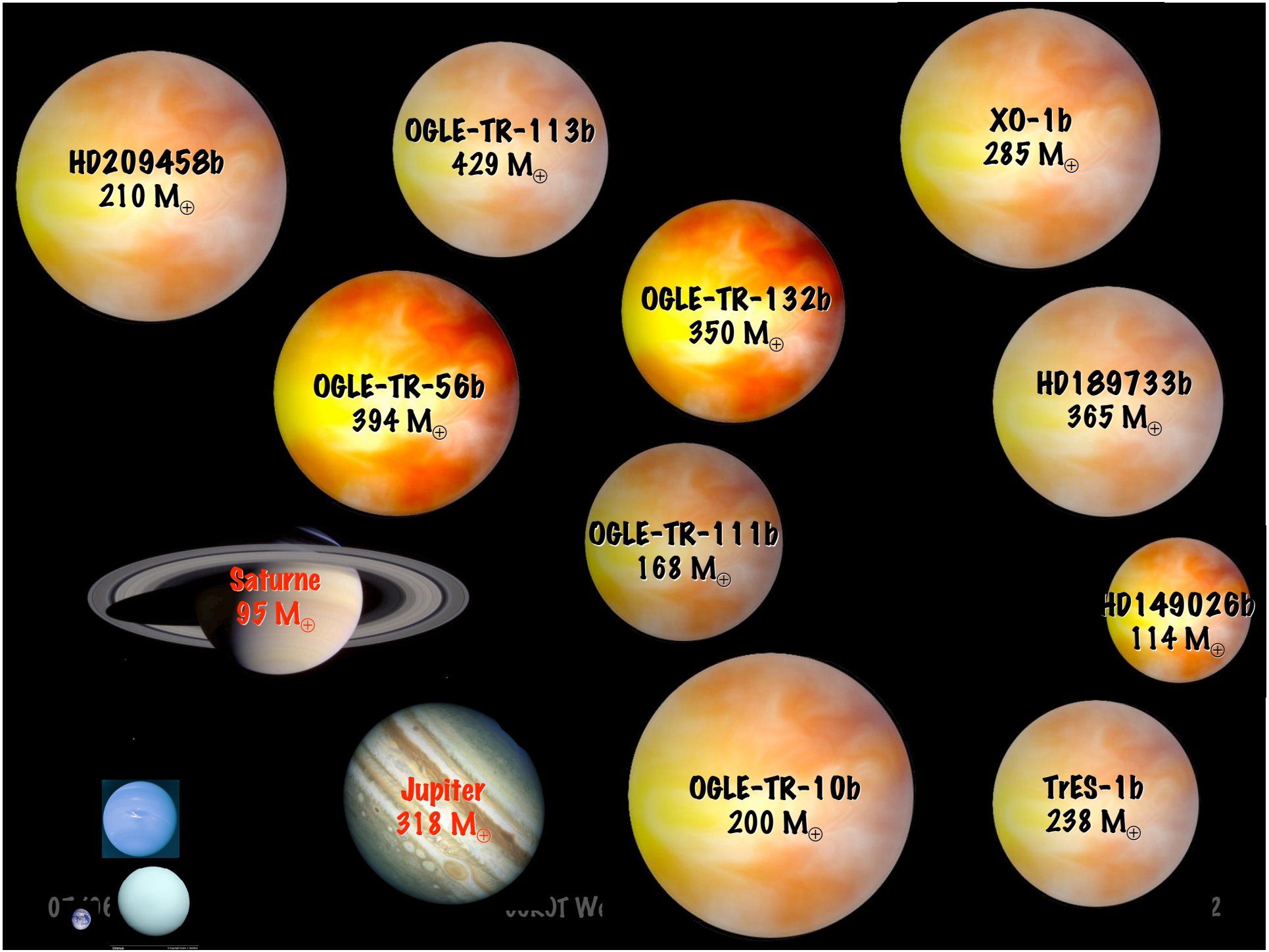
A correlation between the heavy element content of transiting planets and the metallicity of their parent star

Tristan Guillot, Nuno Santos, Frédéric Pont, Nicolas Iro,
Claudio Melo & Ignasi Ribas

A&A, in press (2006)

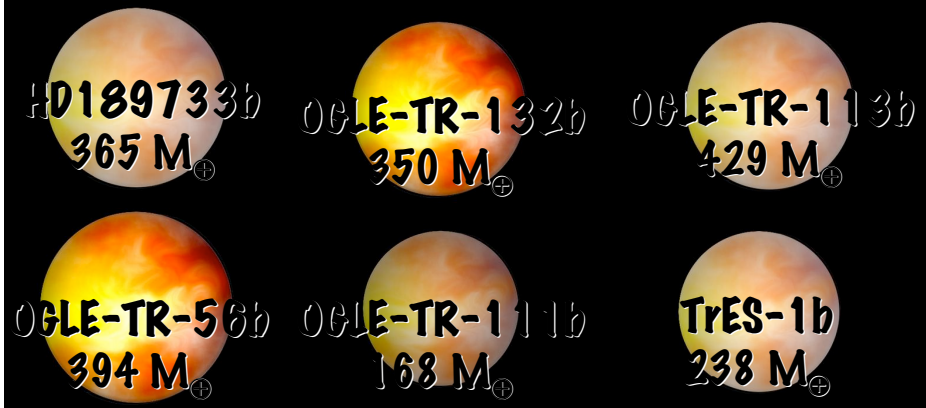



HD209458b
210 M⊕
OGLE-TR-113b
429 M⊕
XO-1b
285 M⊕
OGLE-TR-132b
350 M⊕
OGLE-TR-56b
394 M⊕
HD189733b
365 M⊕
OGLE-TR-111b
168 M⊕
Saturne
95 M⊕
HD149026b
114 M⊕
Jupiter
318 M⊕
OGLE-TR-10b
200 M⊕
TrES-1b
238 M⊕
Uranus
Neptune

9 transiting planets

2 anomalously large planets

Bodenheimer et al. 2001, 2003; Guillot & Showman 2002; Burrows et al. 2003; Baraffe et al. 2003, 2004, 2005; Guillot 2005; Laughlin et al. 2005



6 "normal" planets

Baraffe et al. 2005; Guillot 2005; Laughlin et al. 2005

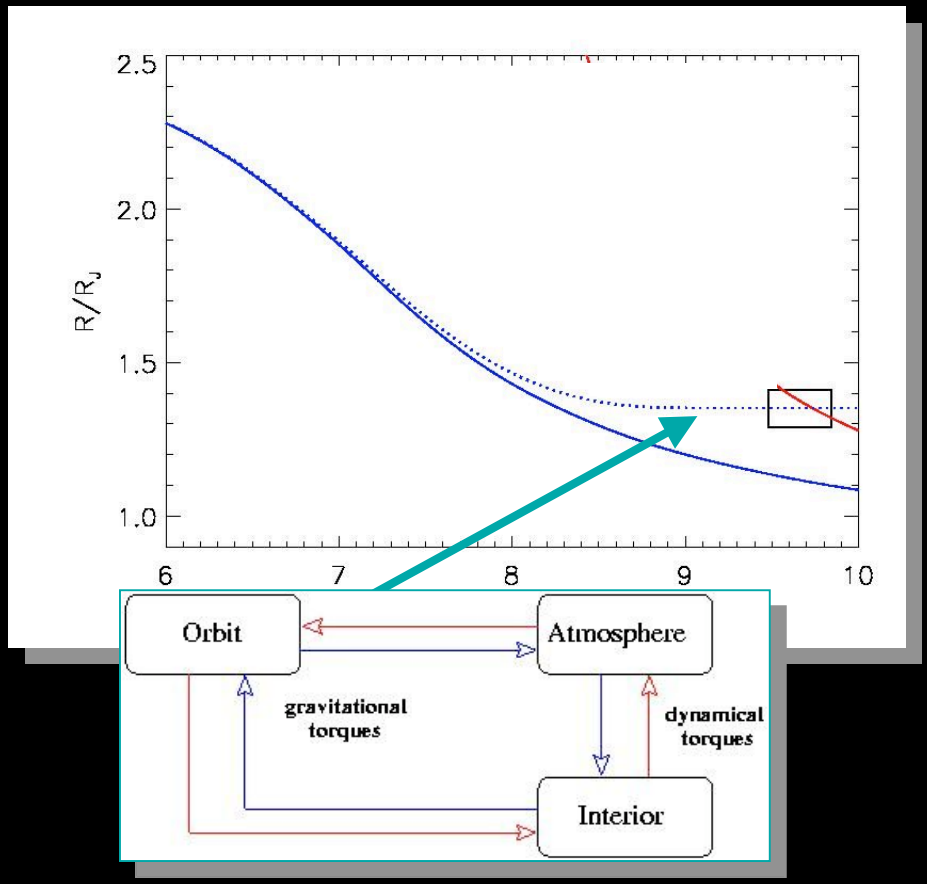
1 small planet with a "big core" $\approx 70 M_\oplus$

Sato et al. 2005; Fortney et al. 2006; Ikoma et al.

Explaining the anomalously large Pegasids

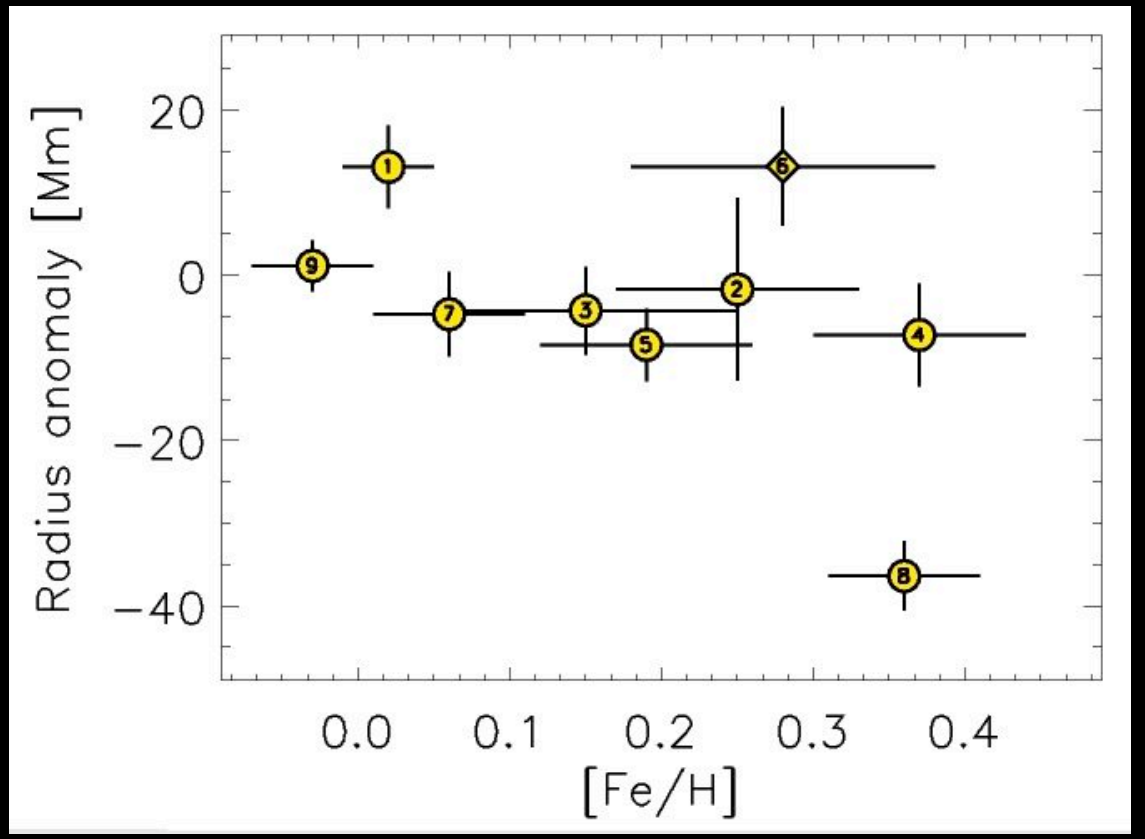
"Missing physics":

- *Eccentricity damping by stellar tides*
  - [Bodenheimer et al. 2001]
  - But new observations imply small e (Laughlin et al. 2005)
- Kinetic energy transport and dissipation by tides
  - [Showman & Guillot 2002]
  - Assumes that transport is possible and dissipation takes place deep enough
- *Transit radius corresponds to P<<1 bar*
  - [Burrows et al. 2003]
  - Has to be included, but too small to explain the observations
- Inclination damping of a planet locked in a Cassini state
  - [Winn & Holman 2005]
- Possible EOS+opacity uncertainties???



9 Pegasids : radius anomalies

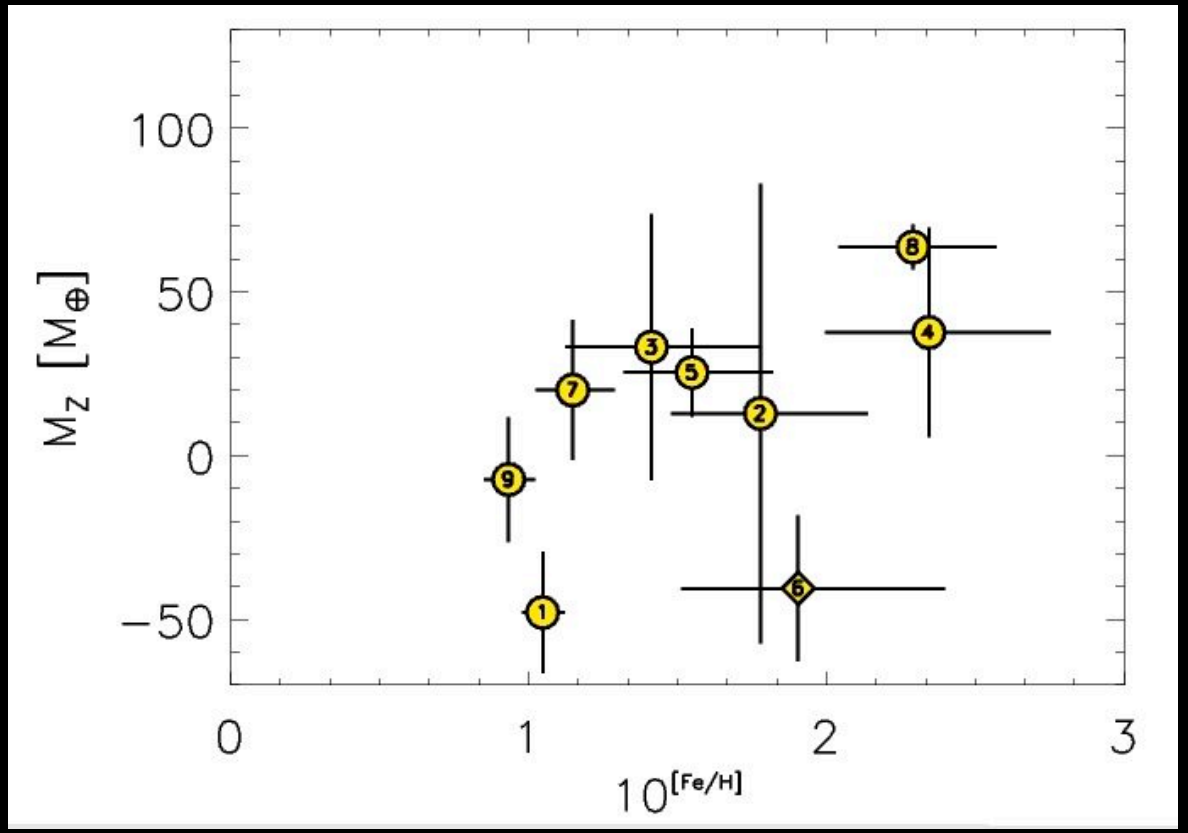
- Uncertainties/missing physics
  - we study all Pegasids with the same hypotheses
- Radius anomaly ΔR
  - difference between the observed radius and that calculated from the contraction of a solar composition planet
  - ΔR >0 => problem (missing physics)
  - ΔR <0 => presence of a massive core
- Comparison with the metallicity [Fe/H] of the parent star



Guillot, Santos, Pont, Iro, Melo & Ribas, A&A (2006)

9 Pegasids: masses of heavy elements

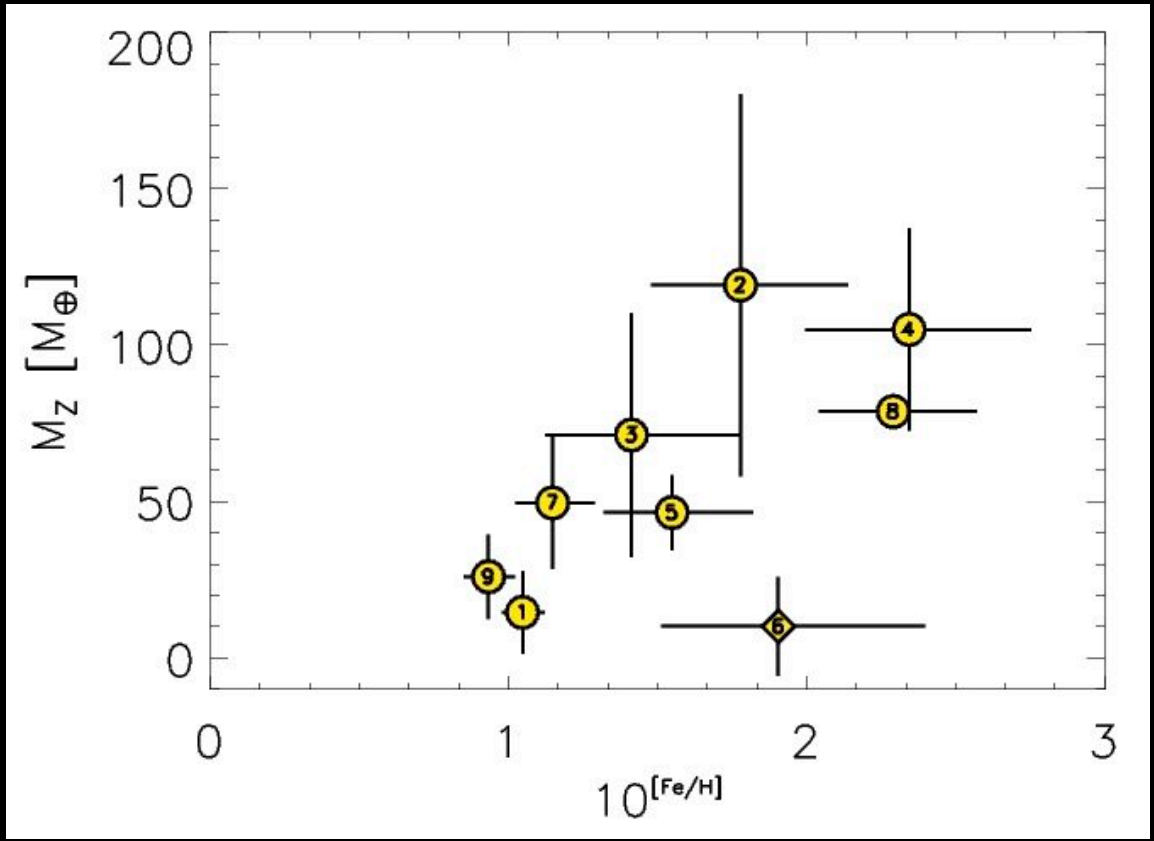
- Calculated on the basis of a standard model
- Anomalously large planets show up as having negative core masses:
  - EOS ?
  - Opacities ?
  - Energy dissipation?



Guillot, Santos, Pont, Iro, Melo & Ribas, A&A (2006)

9 Pegasids: masses of heavy elements

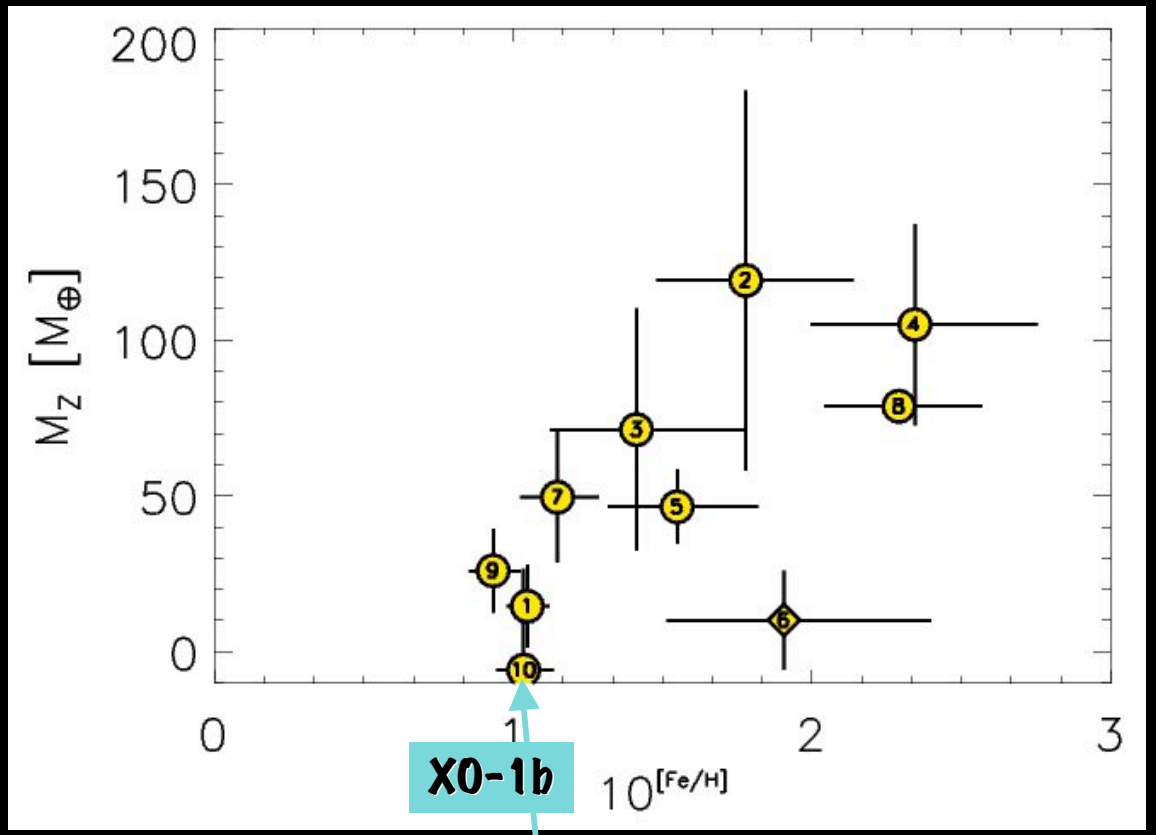
- Calculated on the basis of a non-standard model (Guillot & Showman 2002)
  - Downward transport of kinetic energy created by stellar heating and dissipation due to stellar tides
  - Energy source equivalent to 0.5% of the absorbed stellar energy
- Correlation between stellar and planetary metallicity!



Guillot, Santos, Pont, Iro, Melo & Ribas, A&A (2006)

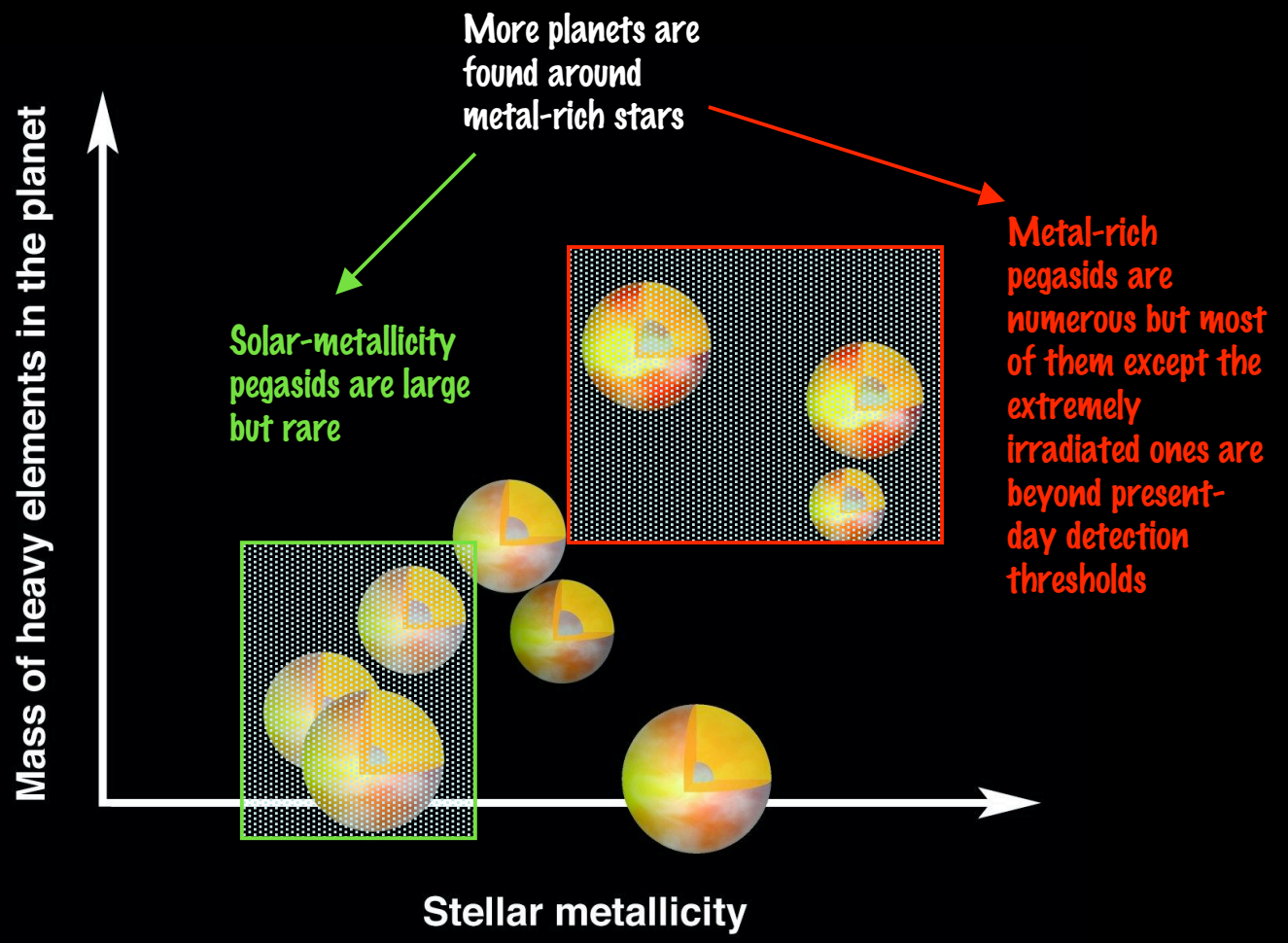
10 Pegasids: masses of heavy elements

- Calculated on the basis of a non-standard model (Guillot & Showman 2002)
  - Downward transport of kinetic energy created by stellar heating and dissipation due to stellar tides
  - Energy source equivalent to 0.5% of the absorbed stellar energy
- Correlation between stellar and planetary metallicity!

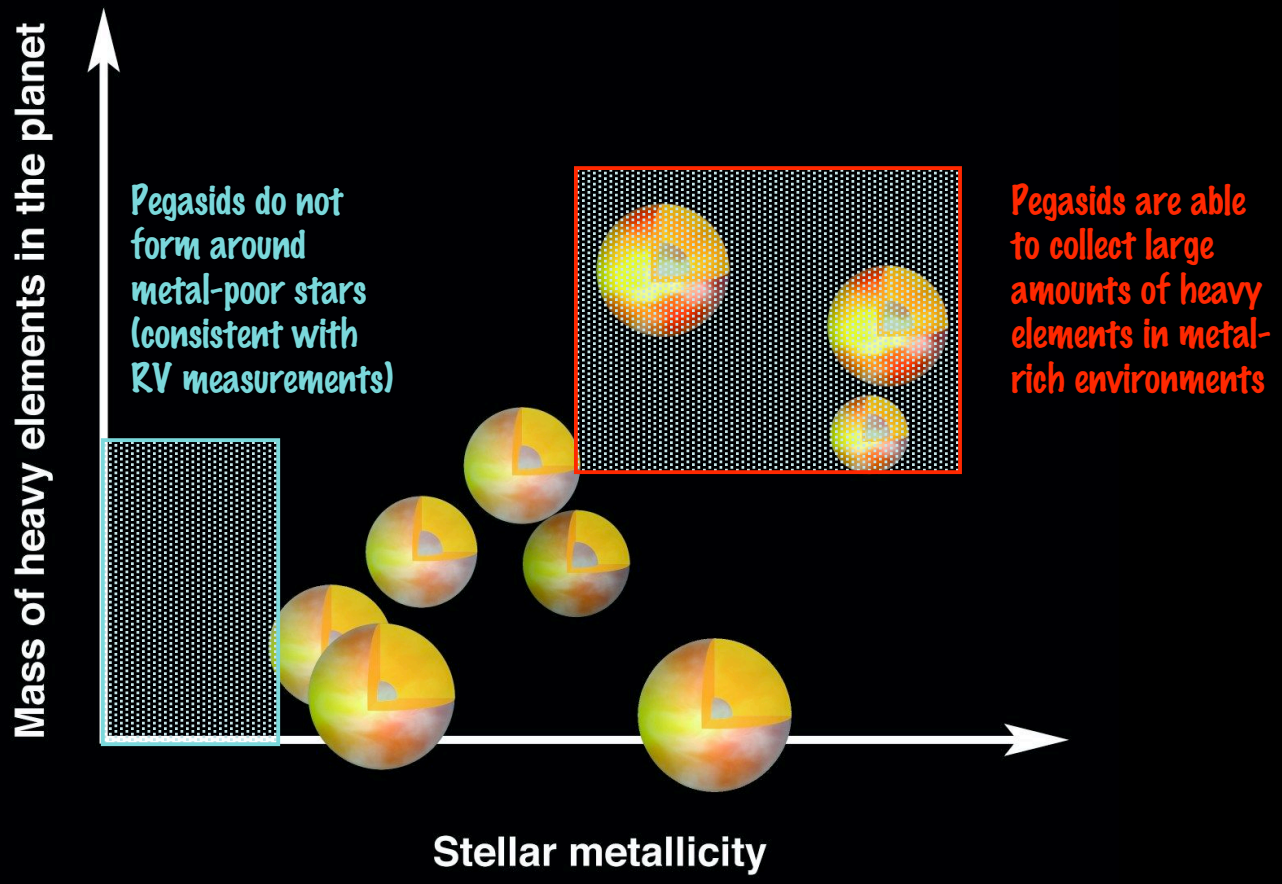


Guillot, Santos, Pont, Iro, Melo & Ribas, A&A (2006)

Consequences for photometric surveys



Consequences for the formation of Pegasids



Exoplanetology is just beginning!

- Giant planets are keys to understand planet formation
  - A better statistics is needed
- Follow-up studies are primordial
  - Basic: Transit (radius) + Radial velocimetry (mass)
  - Stellar parameters:
    - Teff, Mass, Radius
    - Age
    - Metallicity
  - Other properties (but bright stars)
    - Transit spectroscopy
    - Lightcurves
    - ...etc.