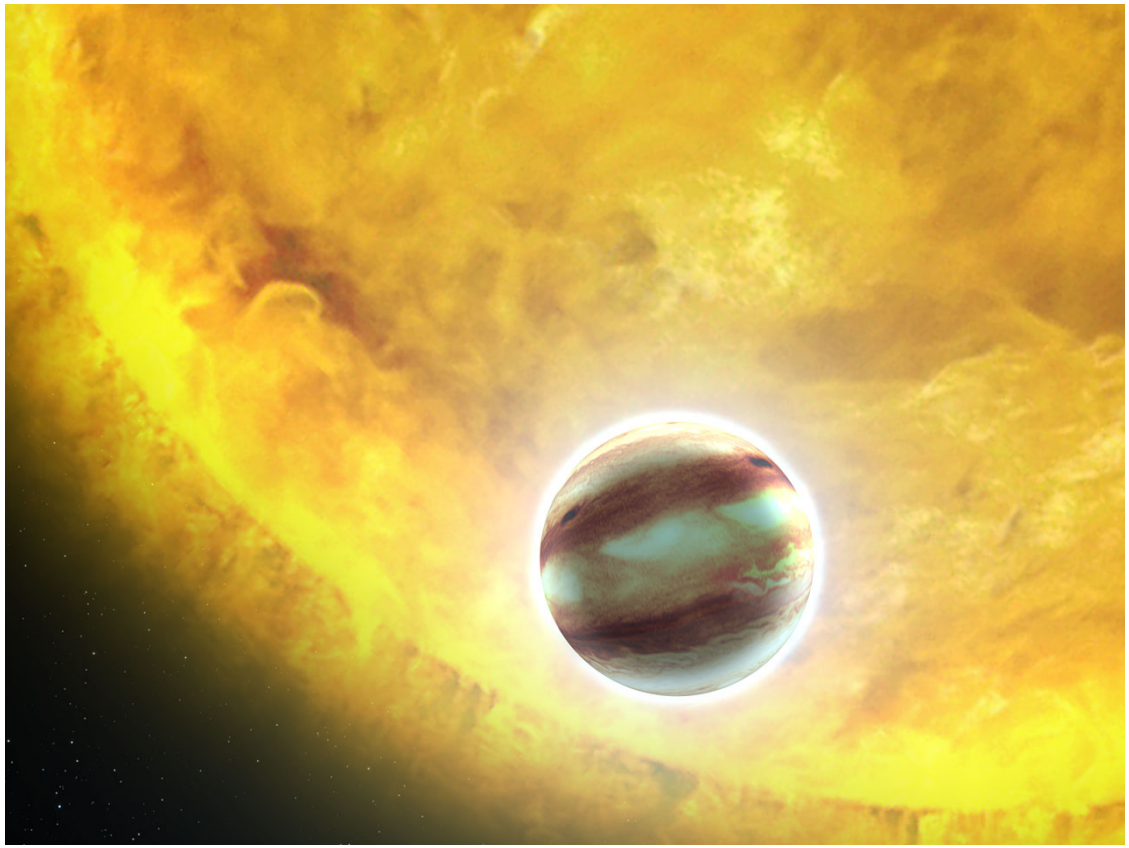
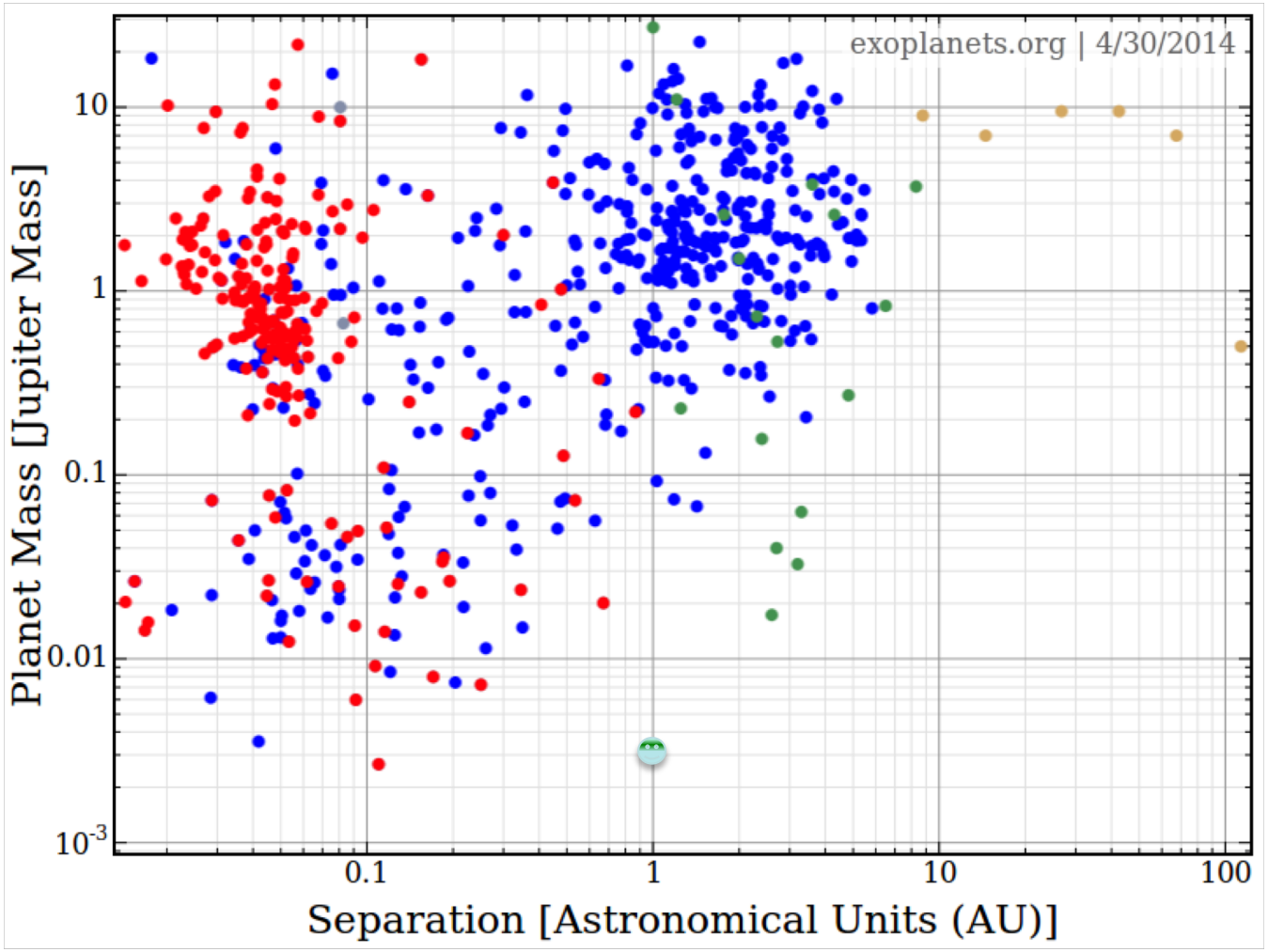
Exo-Planet Properties

- Masses and Orbital radii
- Orbital eccentricities
- Stellar hosts
- Planet formation
- Migration



www.spacetelescope.org/images/ann1114a/

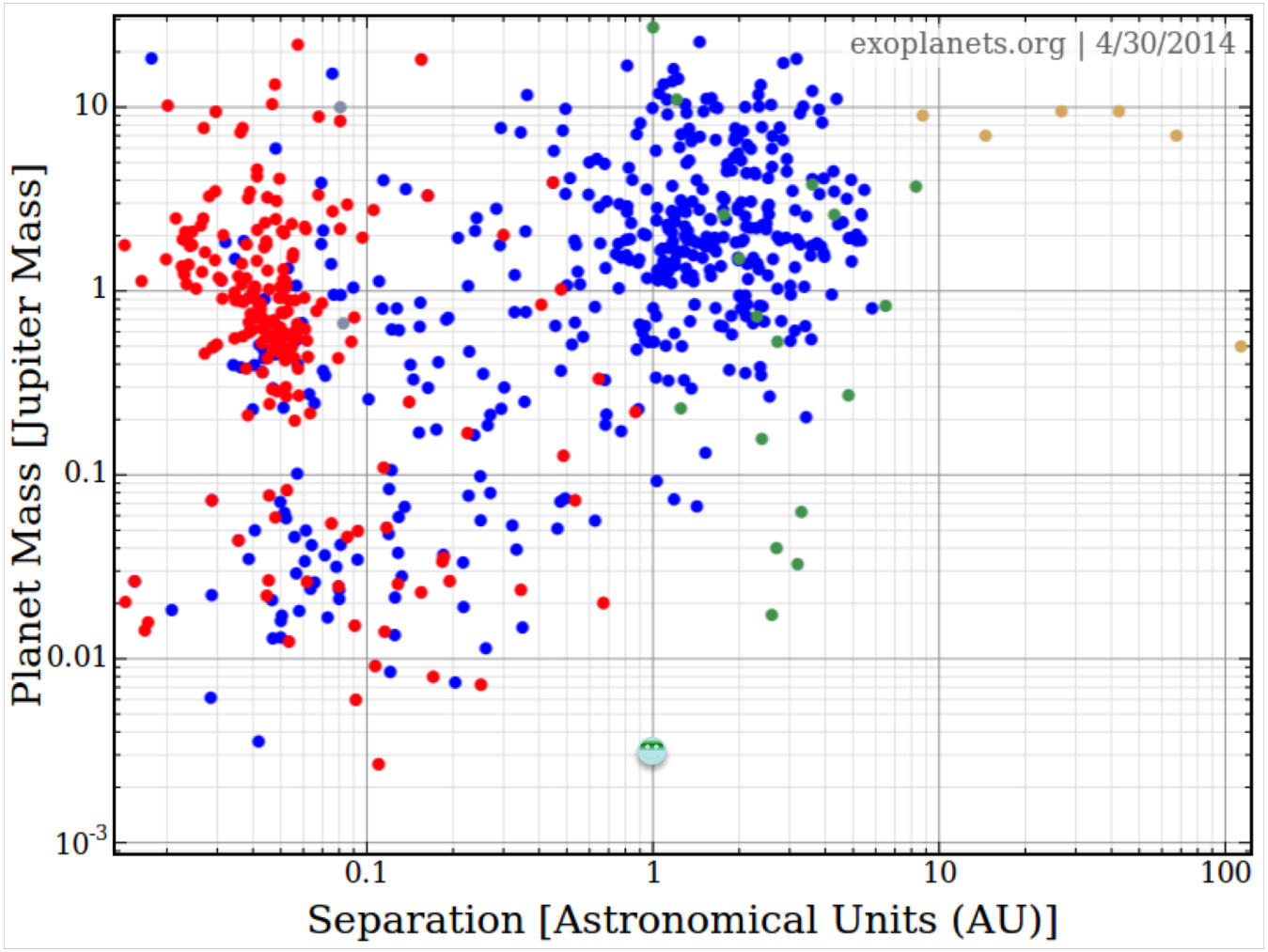
Mass and Separation



This plot only contains planets with masses confirmed by radial velocity method

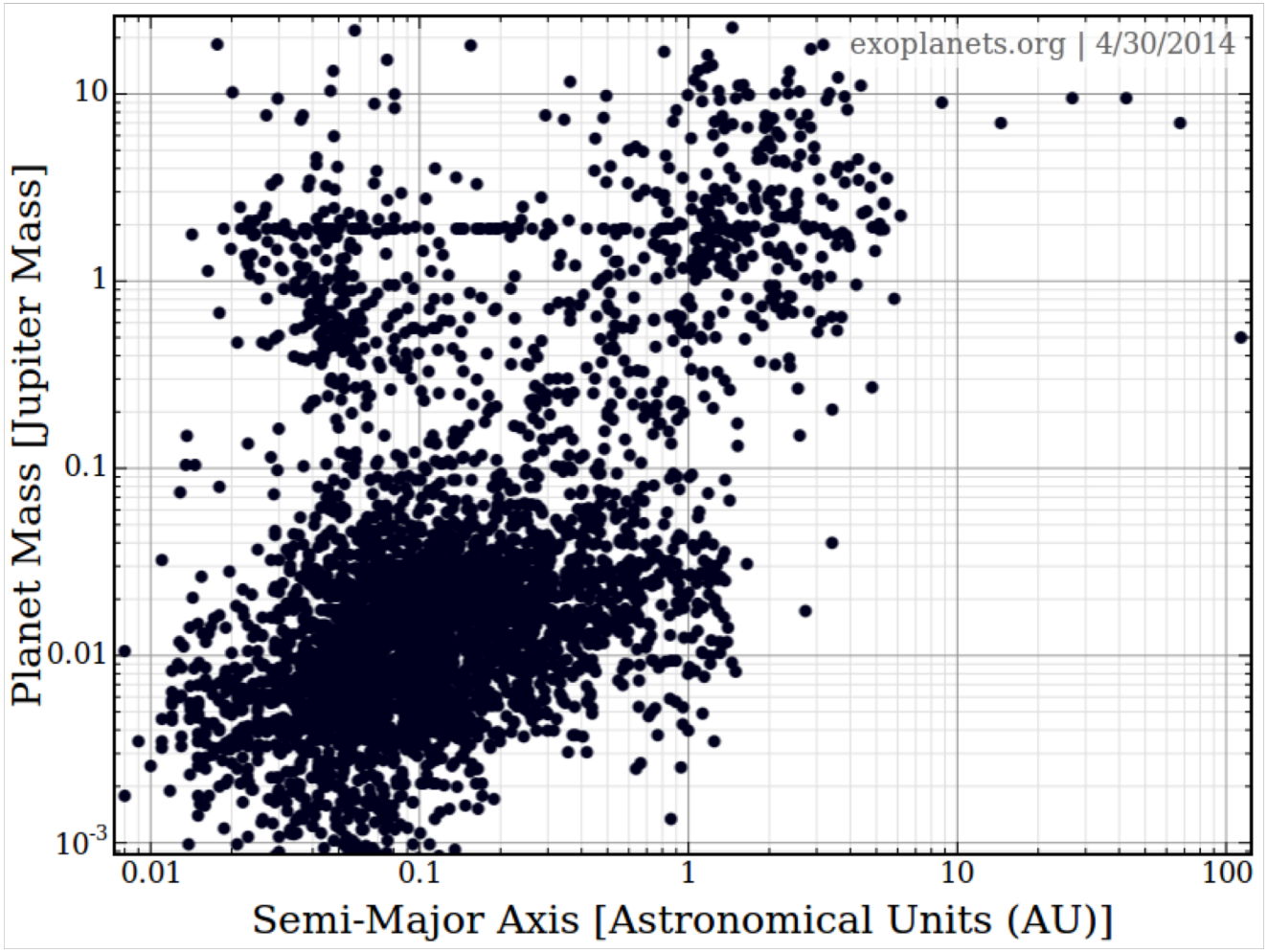
Earth

$M_{Earth} = 0.003 M_{Jupiter}$


exoplanets.org | 4/30/2014
Planet Mass [Jupiter Mass]
10
1
0.1
0.01
10^{-3}
0.1
1
10
100
Separation [Astronomical Units (AU)]
Detection Method
Radial Velocity
Transit
Kepler
Micro-lensing
Direct Imaging

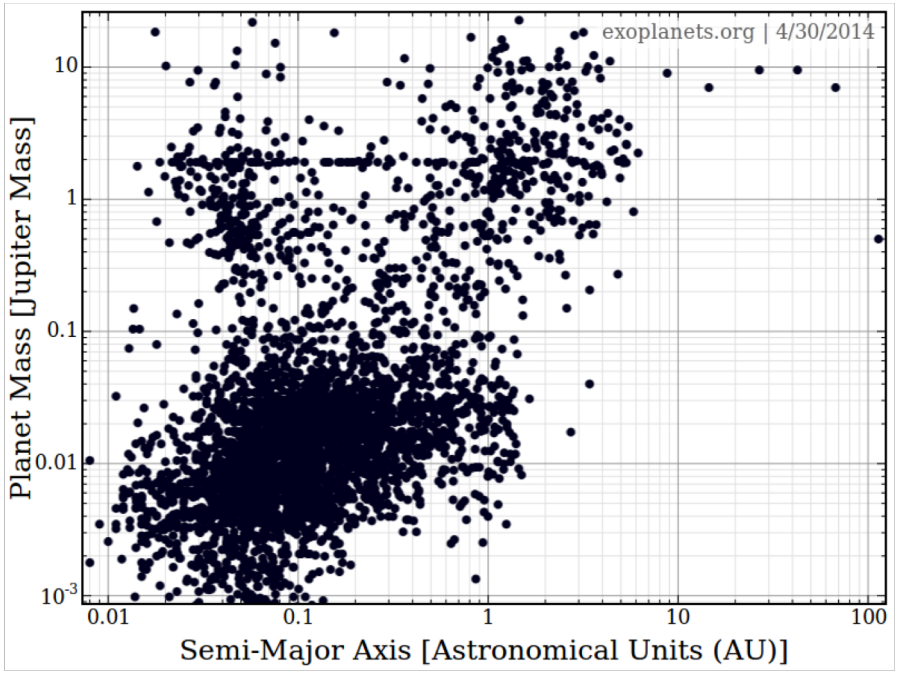
Exo-Planet Populations

- The planets appear to separate into three groups



This plot contains Kepler candidate planets with masses estimated from the measured radius

- Hot Jupiters
  - Massive (Jupiter-mass) planets orbiting very close to their host star
- Jovian planets
  - Similar to the Jovian planets in our solar system although somewhat closer to the star
- Super-Earths
  - A bit more massive than the Earth and closer in

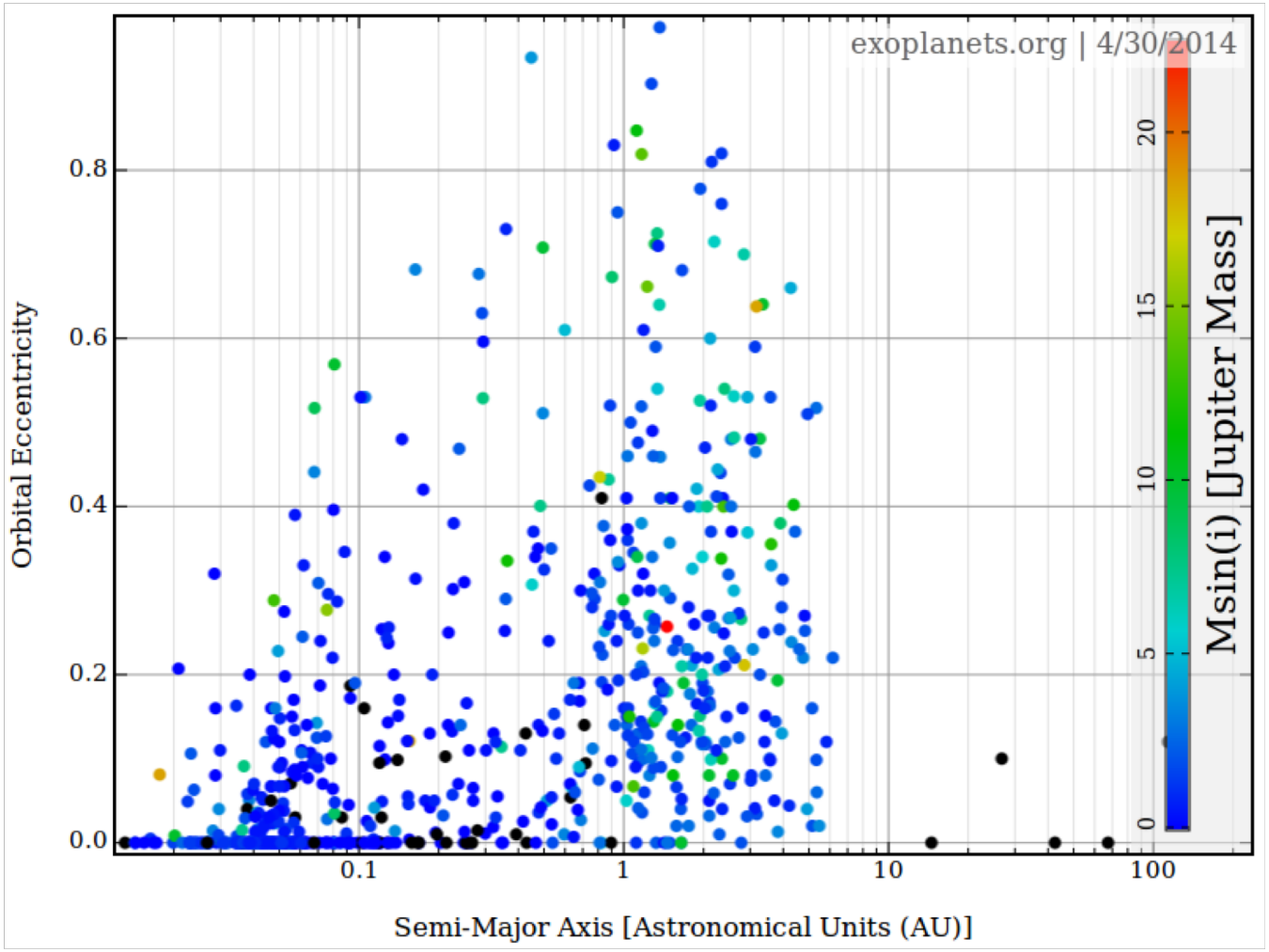


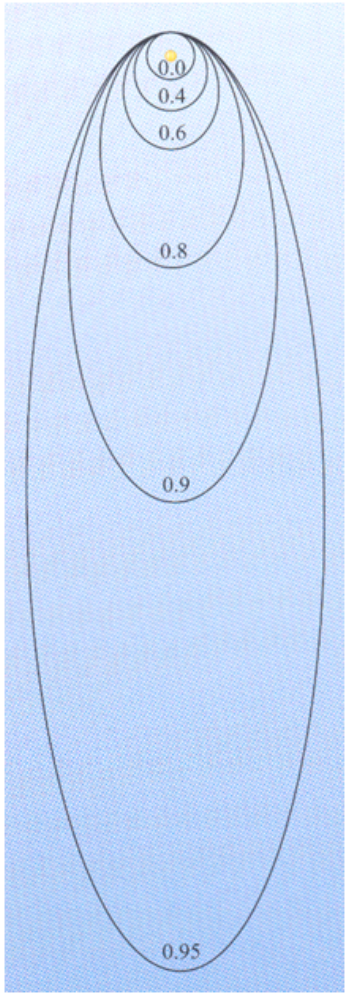
Still many selection effects at work here

- Habitability implications
  - A few Earth analogues in habitable zones beginning to be detected
  - Still many selection effects
  - Earth-mass exo-moons around Jovian planets in the habitable zone?

Orbital Eccentricities

- Many planets with highly eccentric orbits

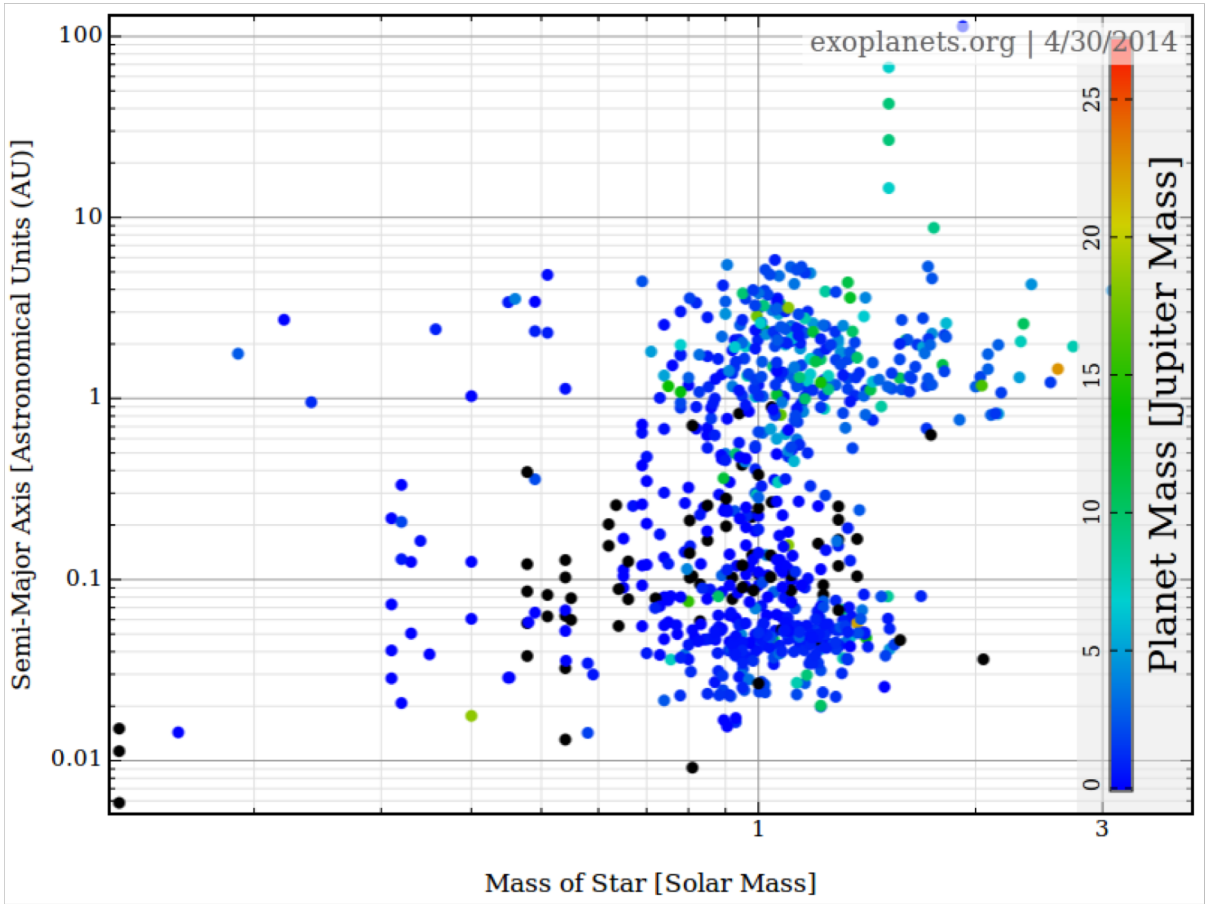




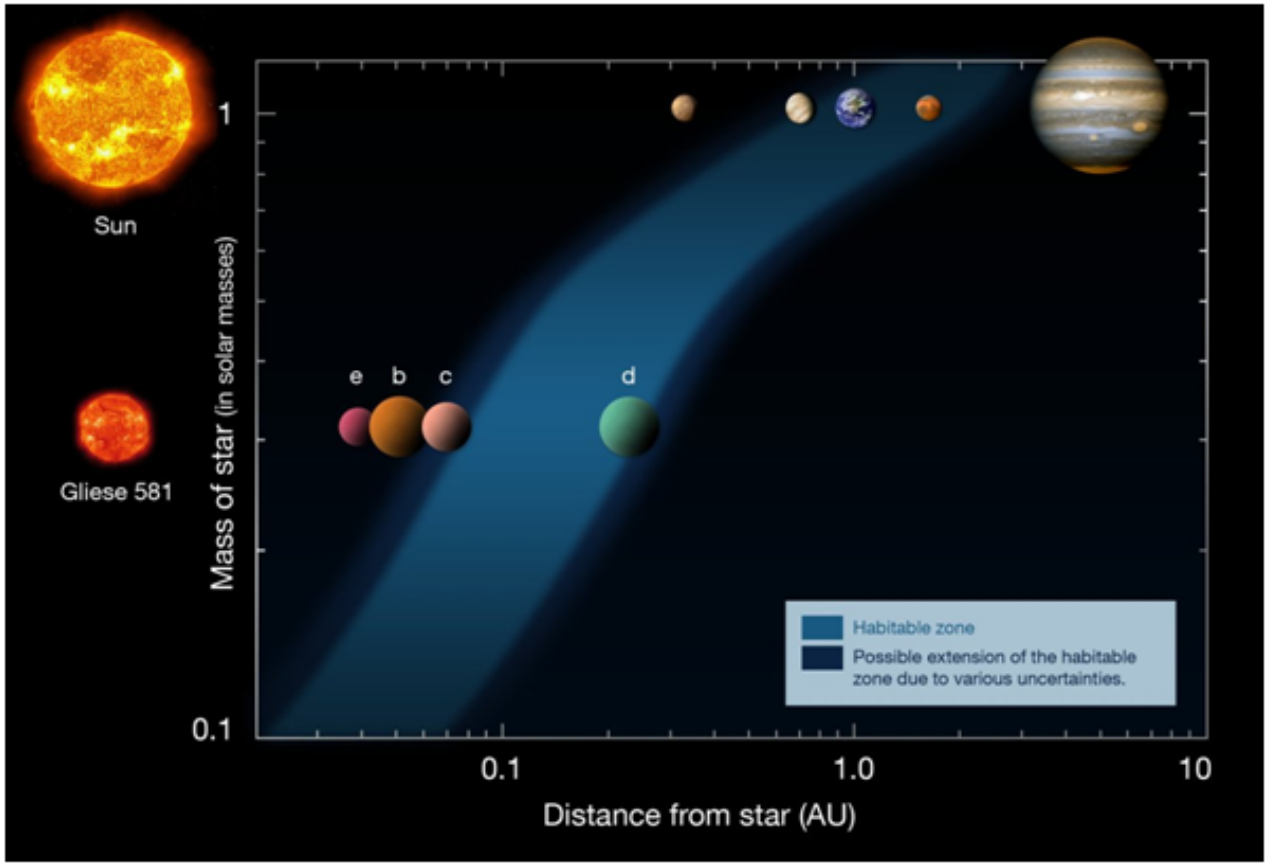
- Habitability implications
  - Would have variable temperature making conditions for life more difficult

Different Stellar Hosts

- Planets have been found around host stars of different masses

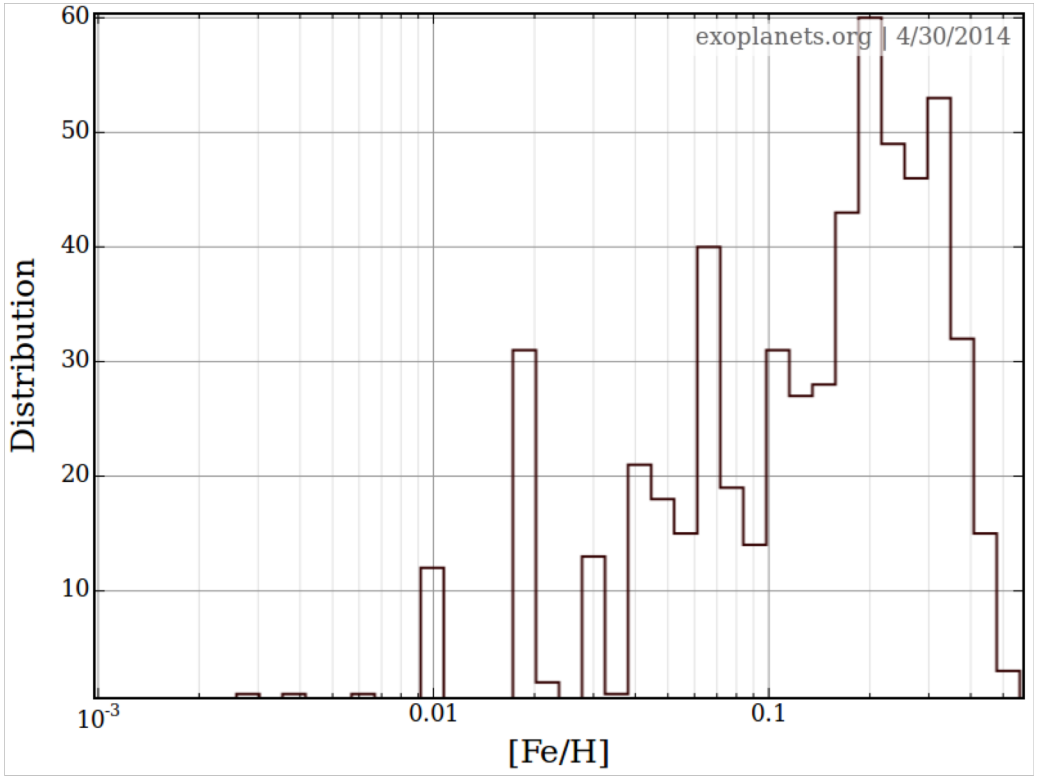


- Habitability implications
  - Habitable zone closer in for lower mass stars so planets already found there
  - But low mass stars are more active and so more harmful solar wind



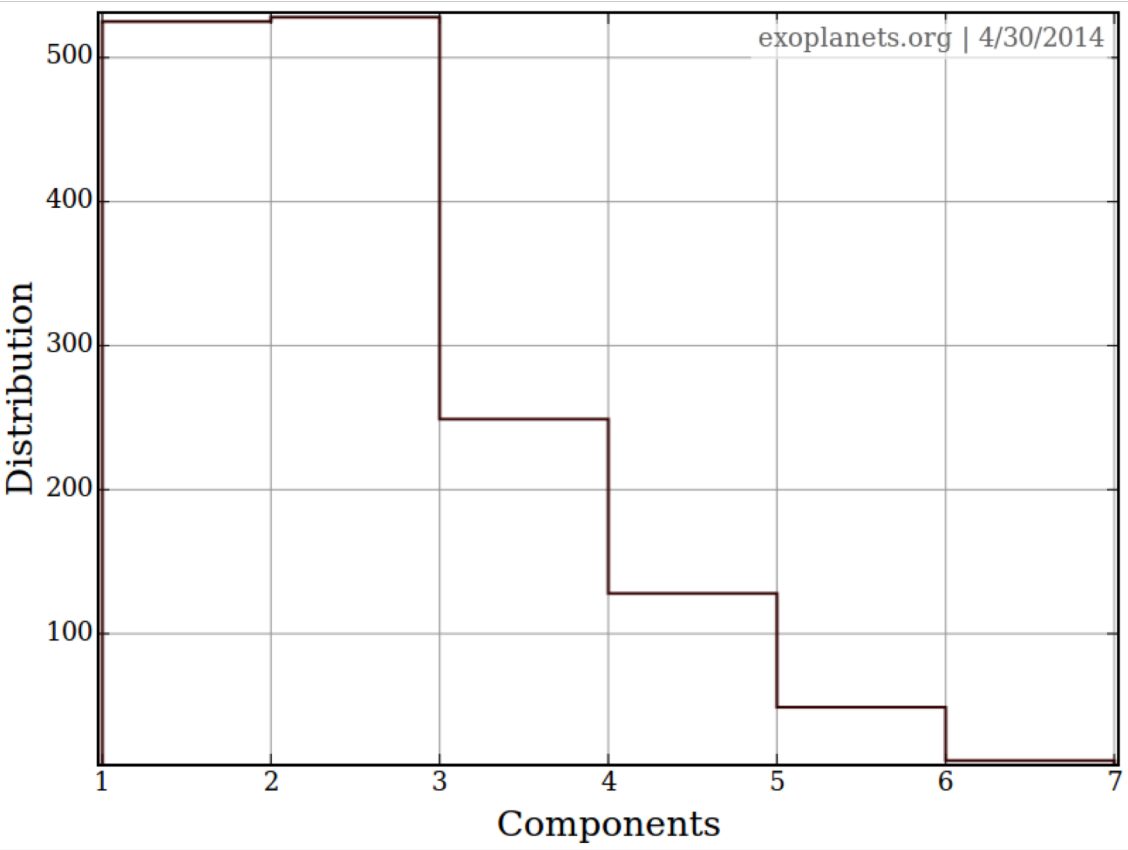
Heavy Element Abundance

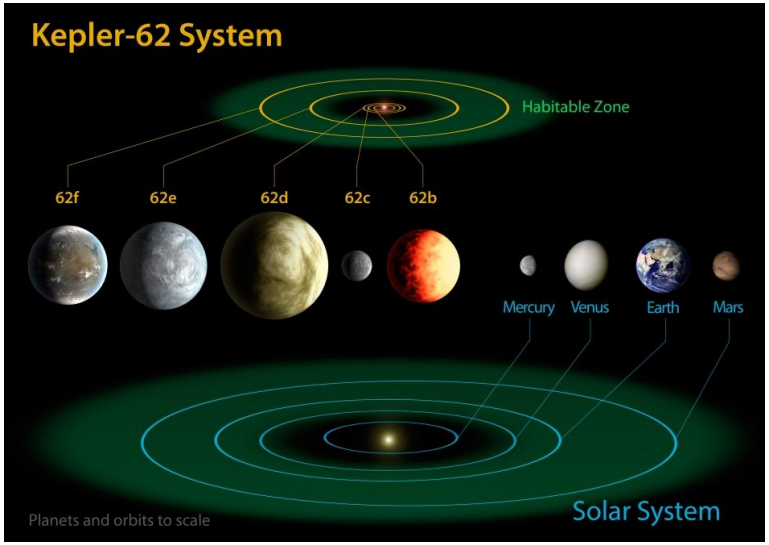
- Planets more likely to be found around stars with more heavy elements in them
- Support for core accretion model



Multiple Planet Systems

- Multiple planet systems are common
- (still many selection effects here)



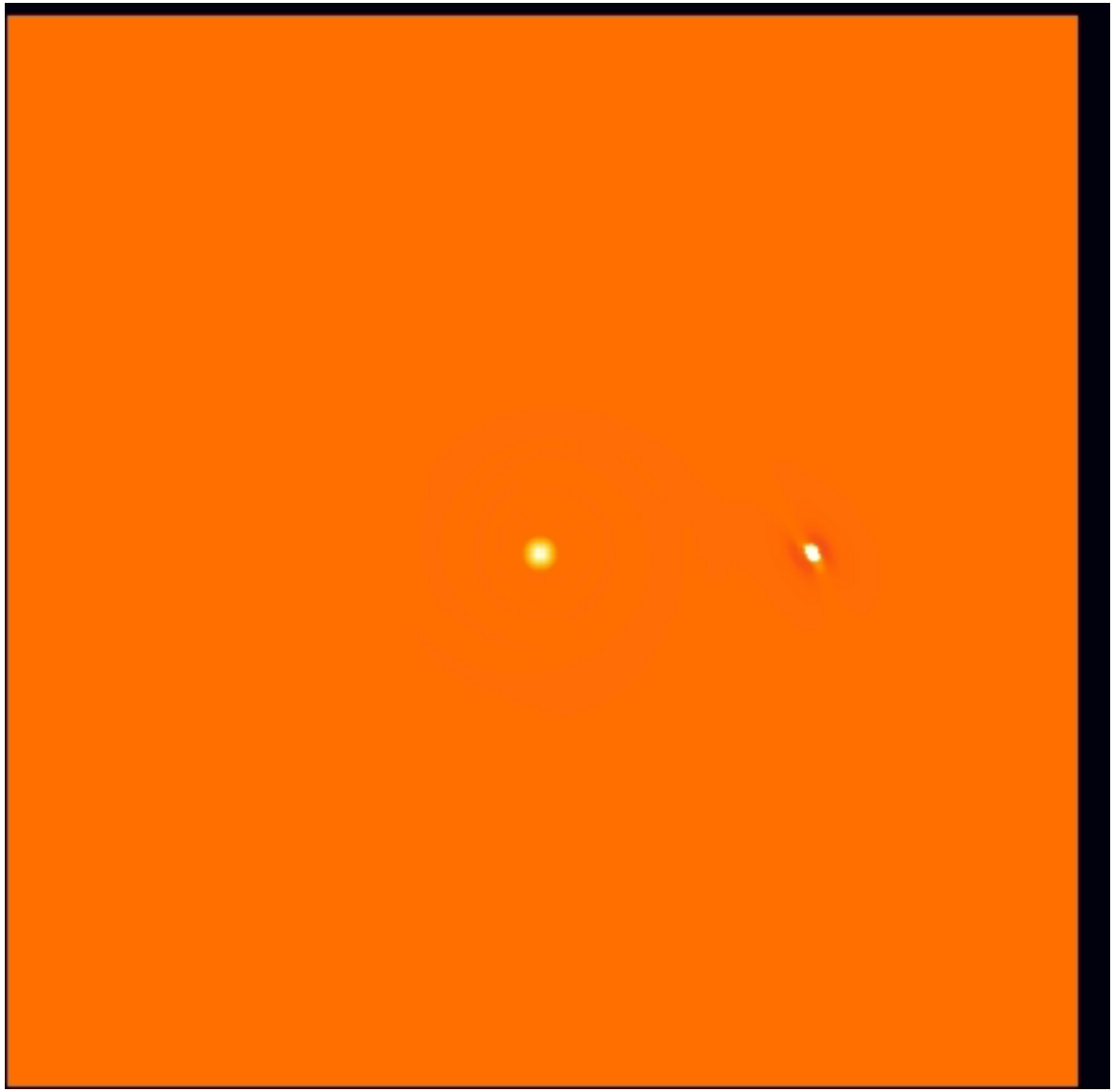


Planet Formation

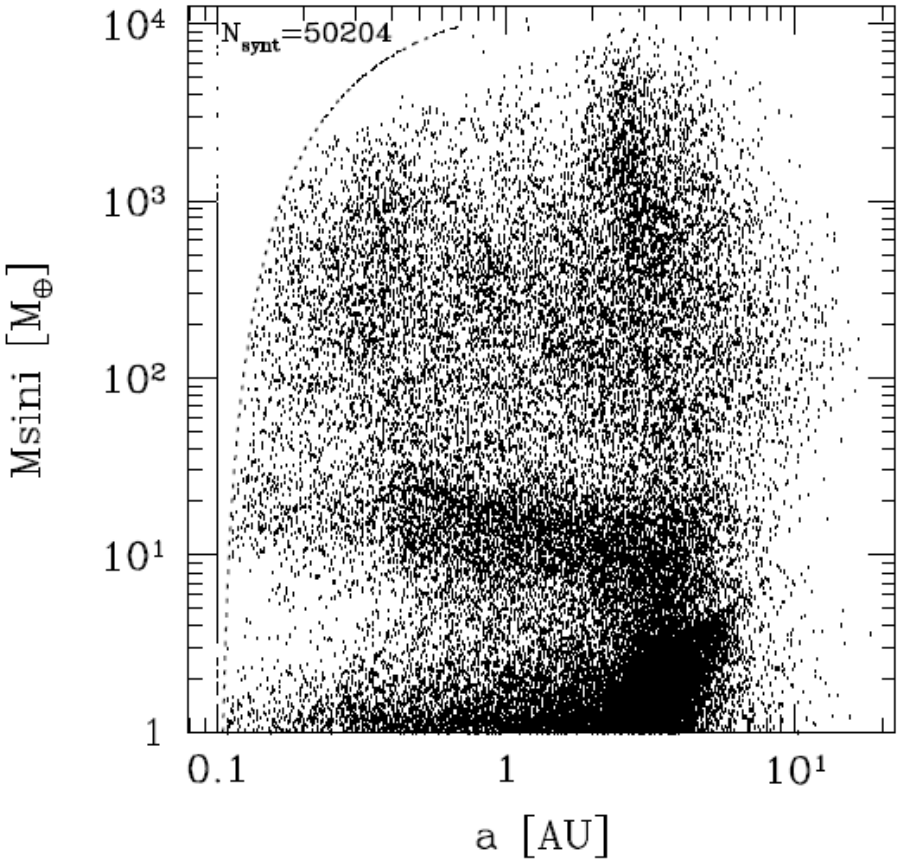
- Exo-planet properties present a challenge to previous solar system formation theory
- How to form Hot Jupiters?
- Current theory is that Jupiter-mass planets must still form outside the snow line via core accretion

Planetary Migration

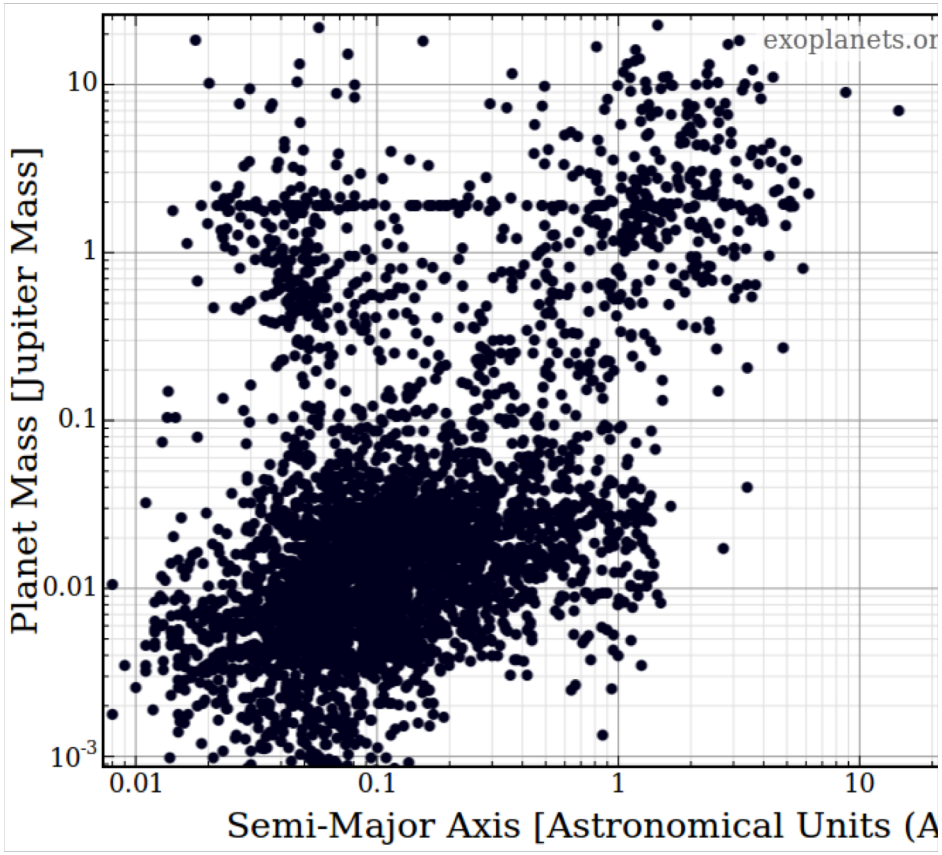
- Interactions between the planet and gas disc cause the planet to migrate inwards

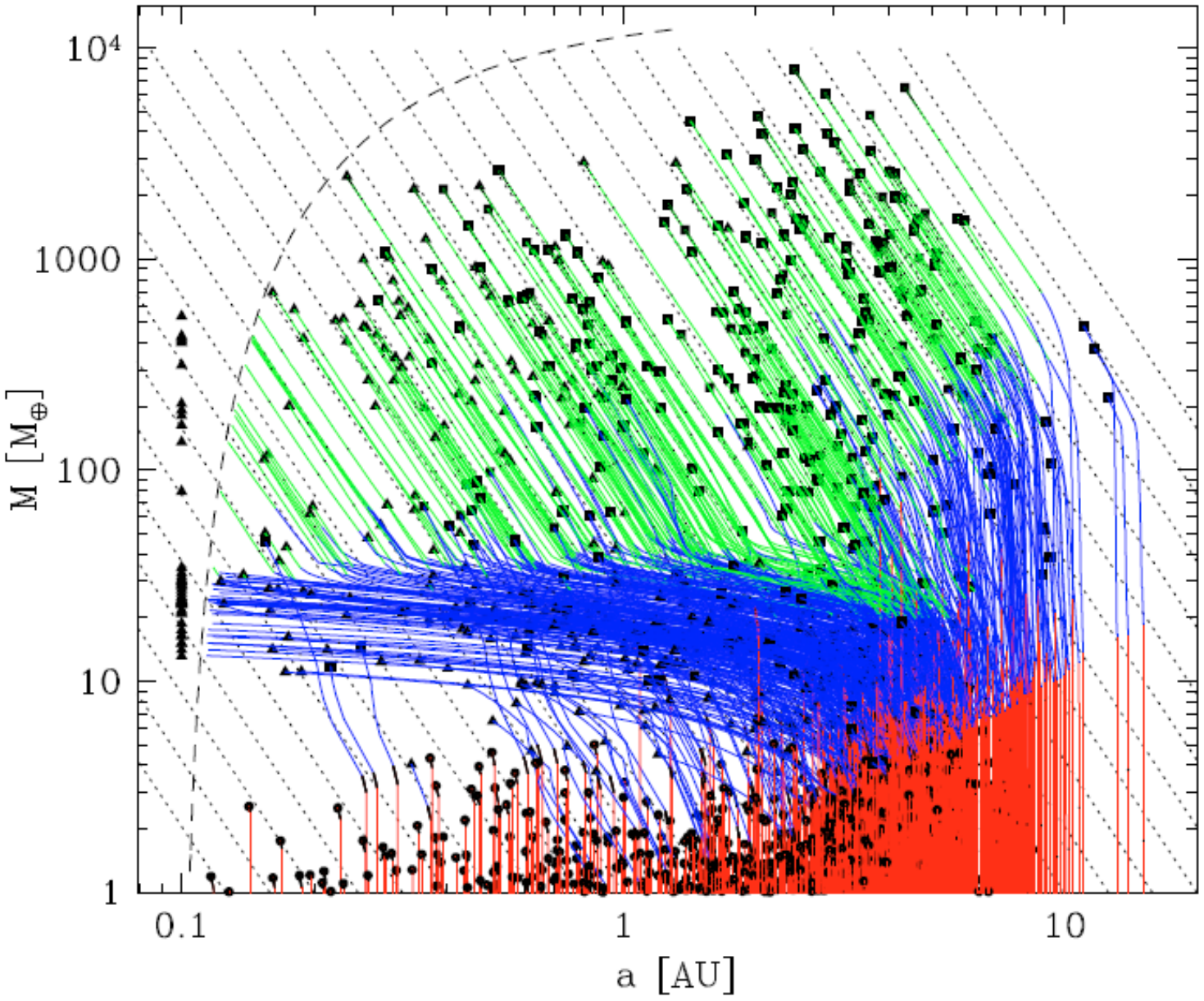


- Planet formation models beginning to predict the different types of exo-planets seen



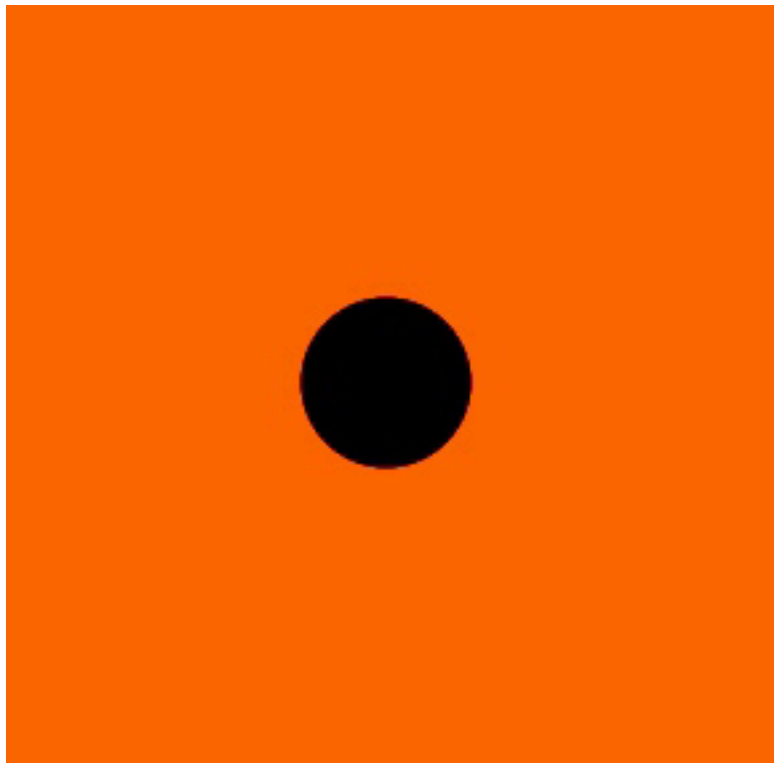
Mordasini et al. (2009)



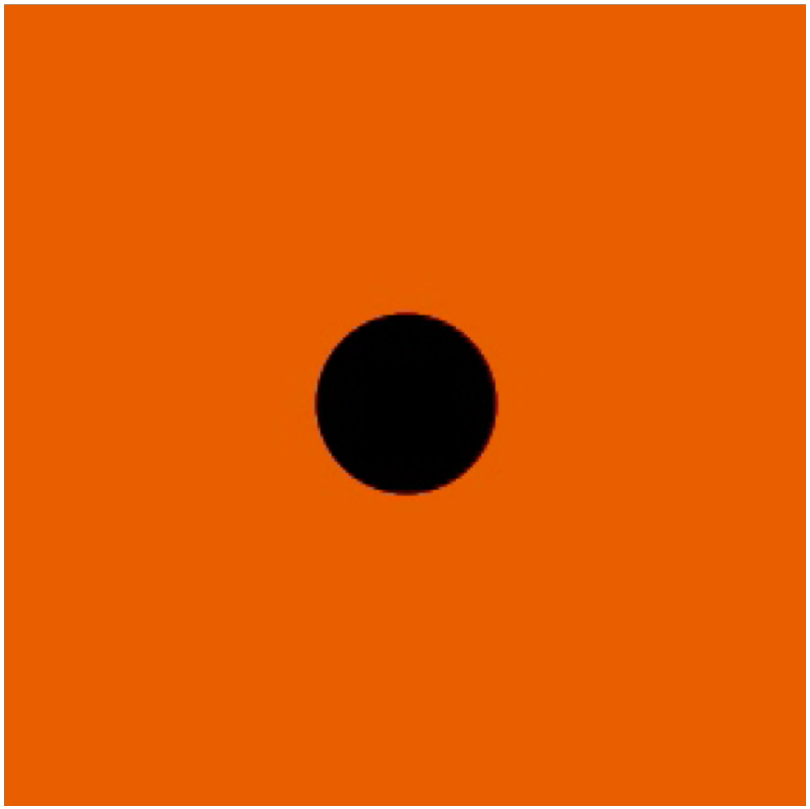


Simulated planet formation tracks. Mordasini et al. (2009).

- Habitability implications
  - Migration will likely scatter any inner terrestrial planets in these systems.
  - Migration is likely to lead to more eccentric orbits.



- Gaps in planet-forming disks
  - Similar processes can open up gaps in disks
  - Gaps often seen in ALMA imaging of protoplanetary systems



Summary

- Most exo-planets and systems discovered so far are significantly different from the solar system
- This is changing our understanding of how planets form
- Few habitable exo-planets discovered so far but number will increase

- Add planet density to this lecture