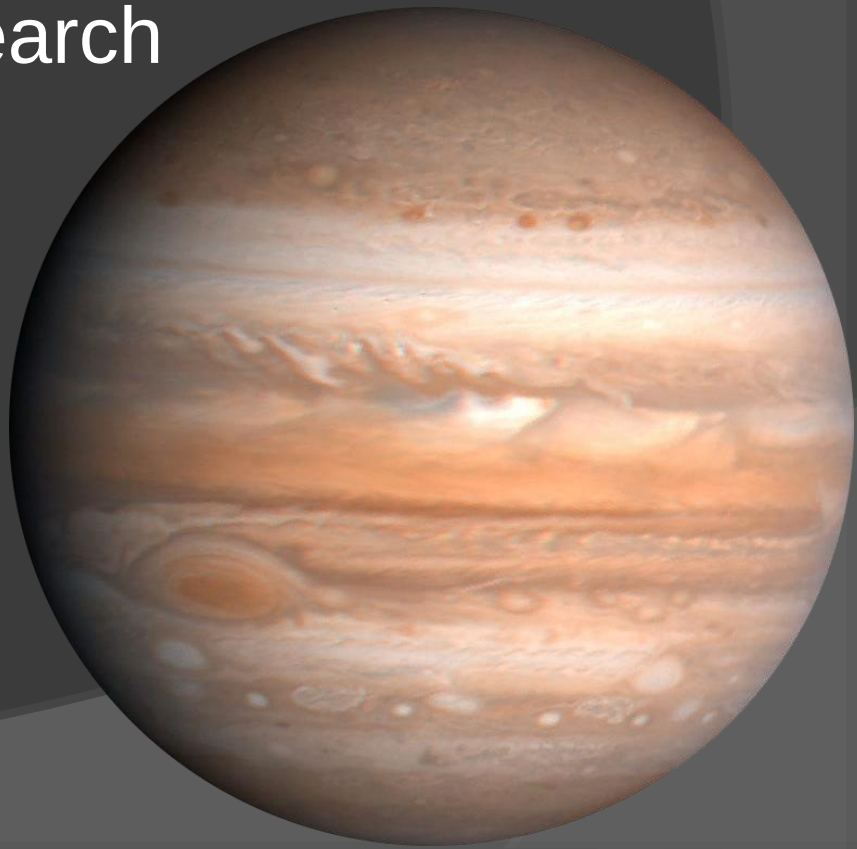
HUNTING FOR PLANETS WITH THE McDONALD OBSERVATORY 2.7m TELESCOPE

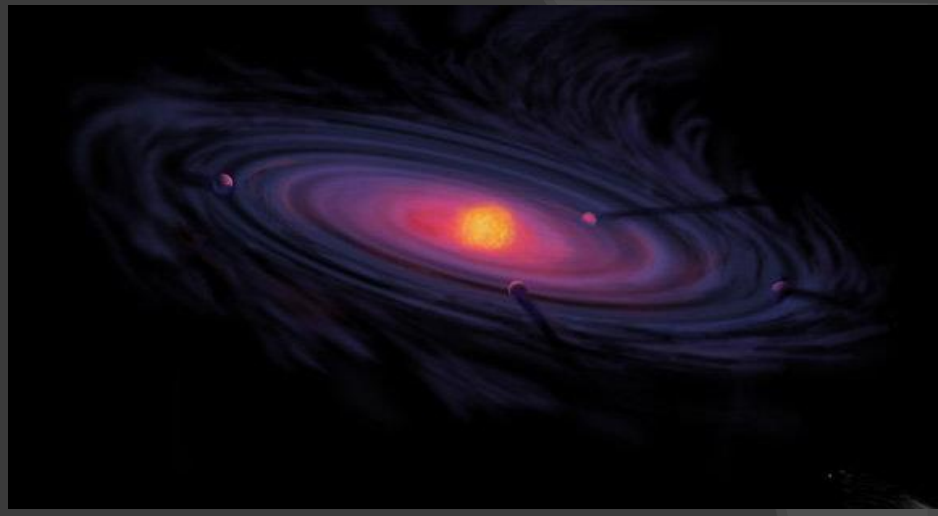
THE UNIVERSITY OF TEXAS AT AUSTIN
ASTRONOMY PROGRAM

Summary of Talk

- Introduction and Background
- Radial Velocity planet search
- Transit/Eclipse planet search
  - Kepler follow-up
- Latest exciting news



Introduction

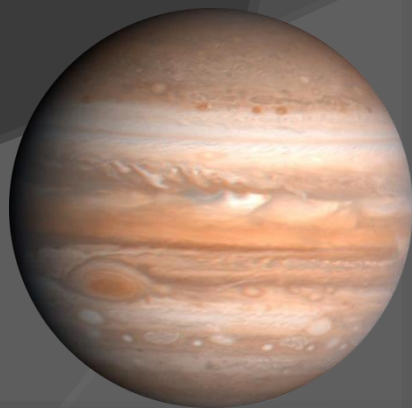


- Long suspected that “extrasolar” planets exist
  - “This space we declare to be infinite... In it are an infinity of worlds of the same kind as our own.”

    -Giordano Bruno (1584)
- When a star forms, leftover material (gas & dust) remains in a disk
- Planets condense out of the disk and grow by collecting disk material

Background

- So, we “know” they’re out there…
- How do we find them?

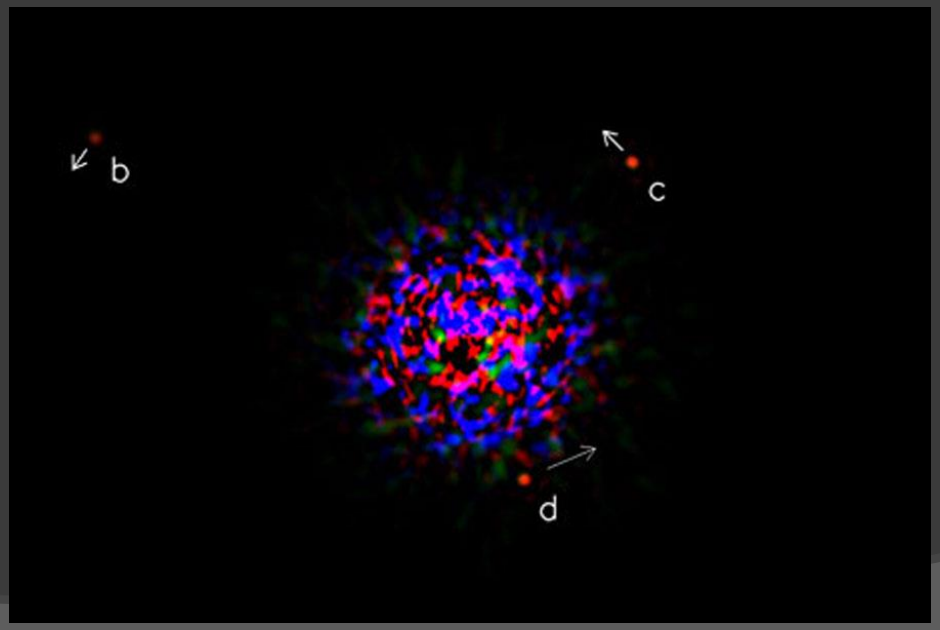


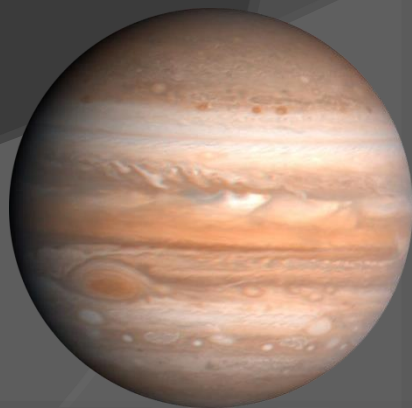

Stars are a billion times brighter…


...than the planet
...hidden
in the glare.

Background

- It is currently very difficult to directly photograph exoplanets
- Instead, astronomers look at *stars* for indirect evidence of planets orbiting them





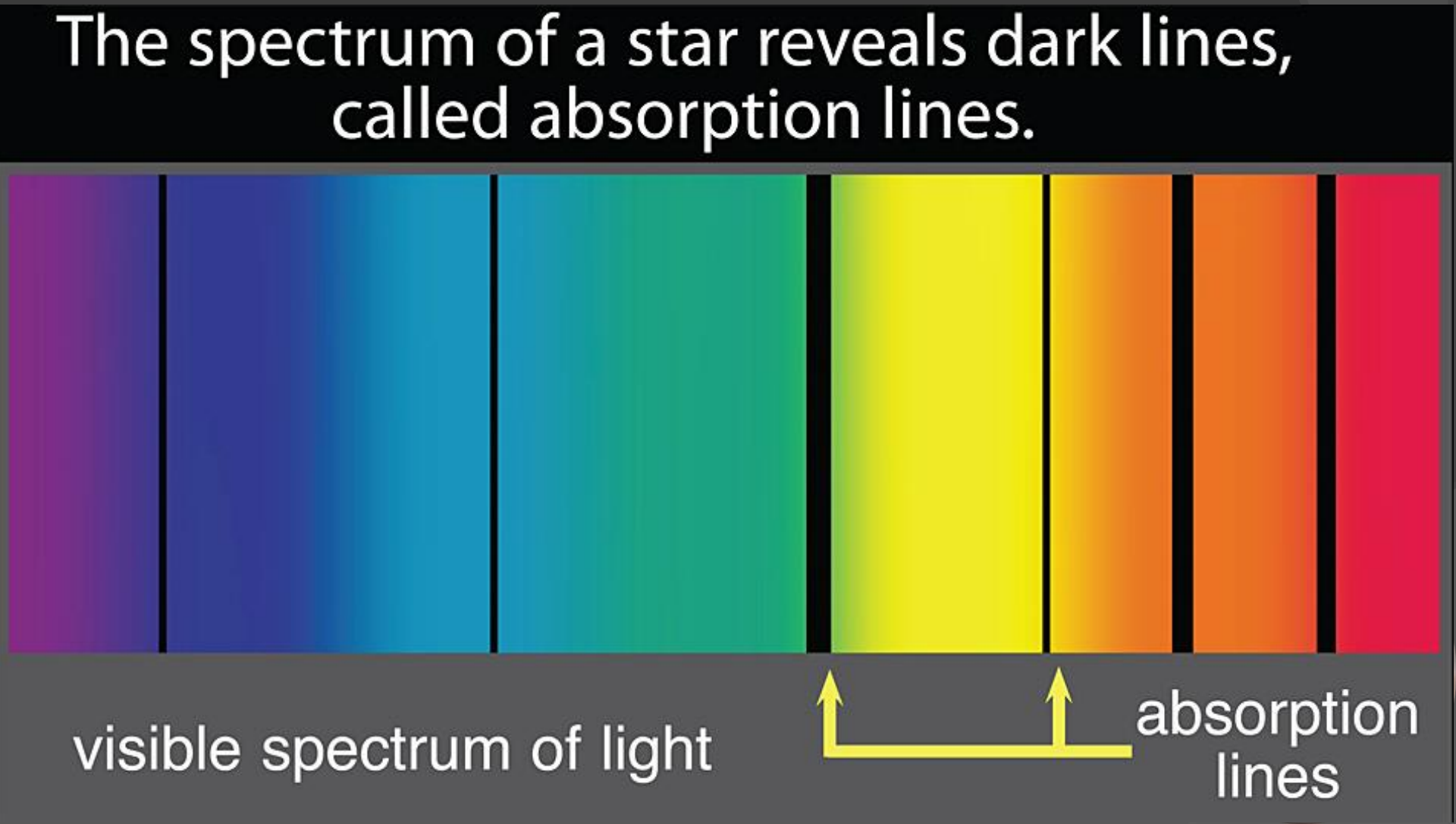
Indirect Planet Detection Methods

- Most common: (more on these later)
  - Radial velocity: 516 planets
    - Done here at McDonald
  - Transiting: 308 planets
    - Follow-up done here
- More rare
  - Gravitational Microlensing: 21 planets
  - Astrometric: 1 planet

Radial Velocity Technique

- Three key parts of process:
  - Spectrum of starlight reveals dark absorption lines
  - Stars “wobble” as planets orbit them (astrometric)
  - This wobble produces a “Doppler Effect”
    - Star moves towards us → light appears bluer
    - Star moves away from us → light appears redder
- Put it all together: as planet orbits, the absorption lines change position over time

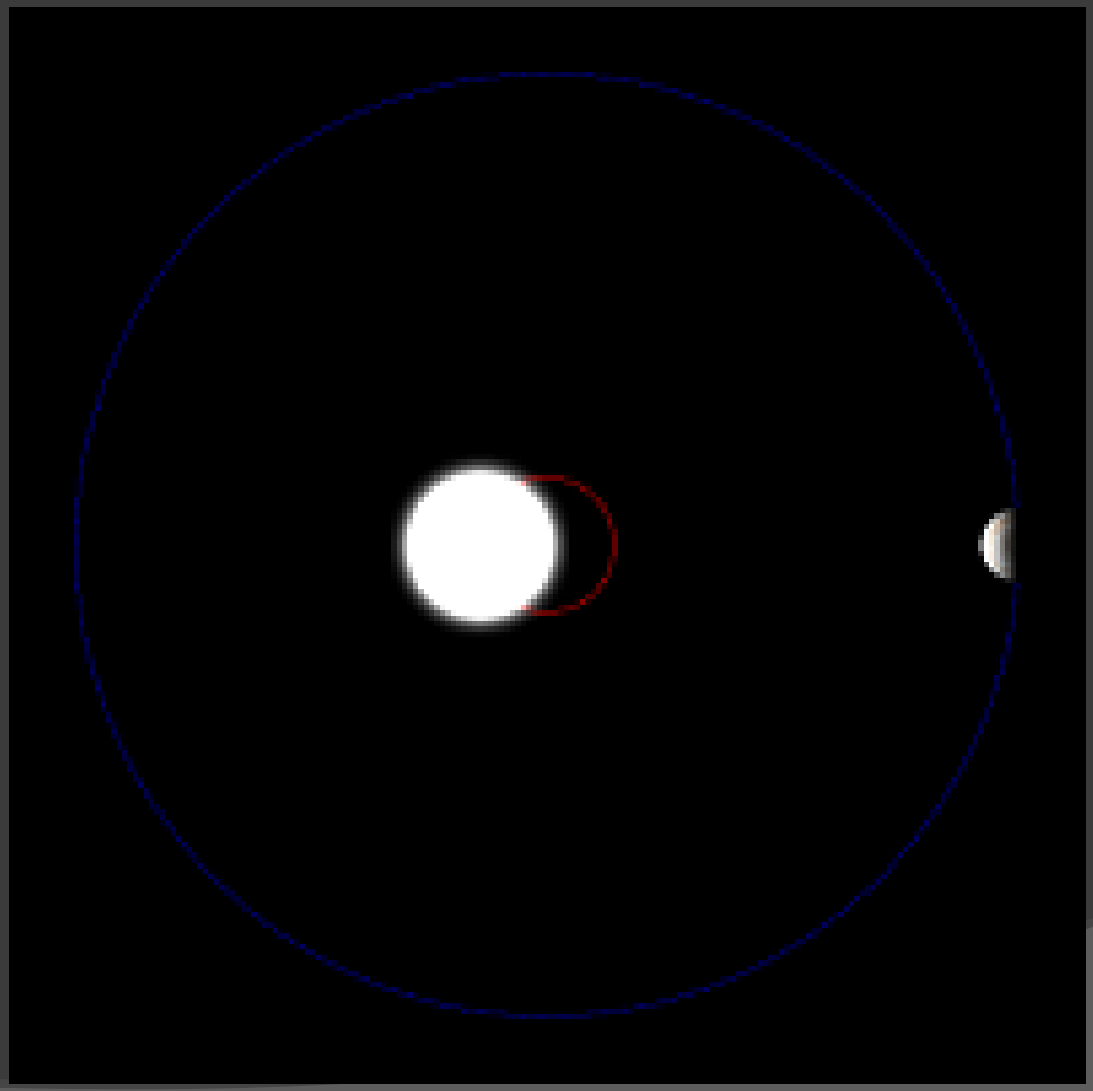
Radial Velocity Technique



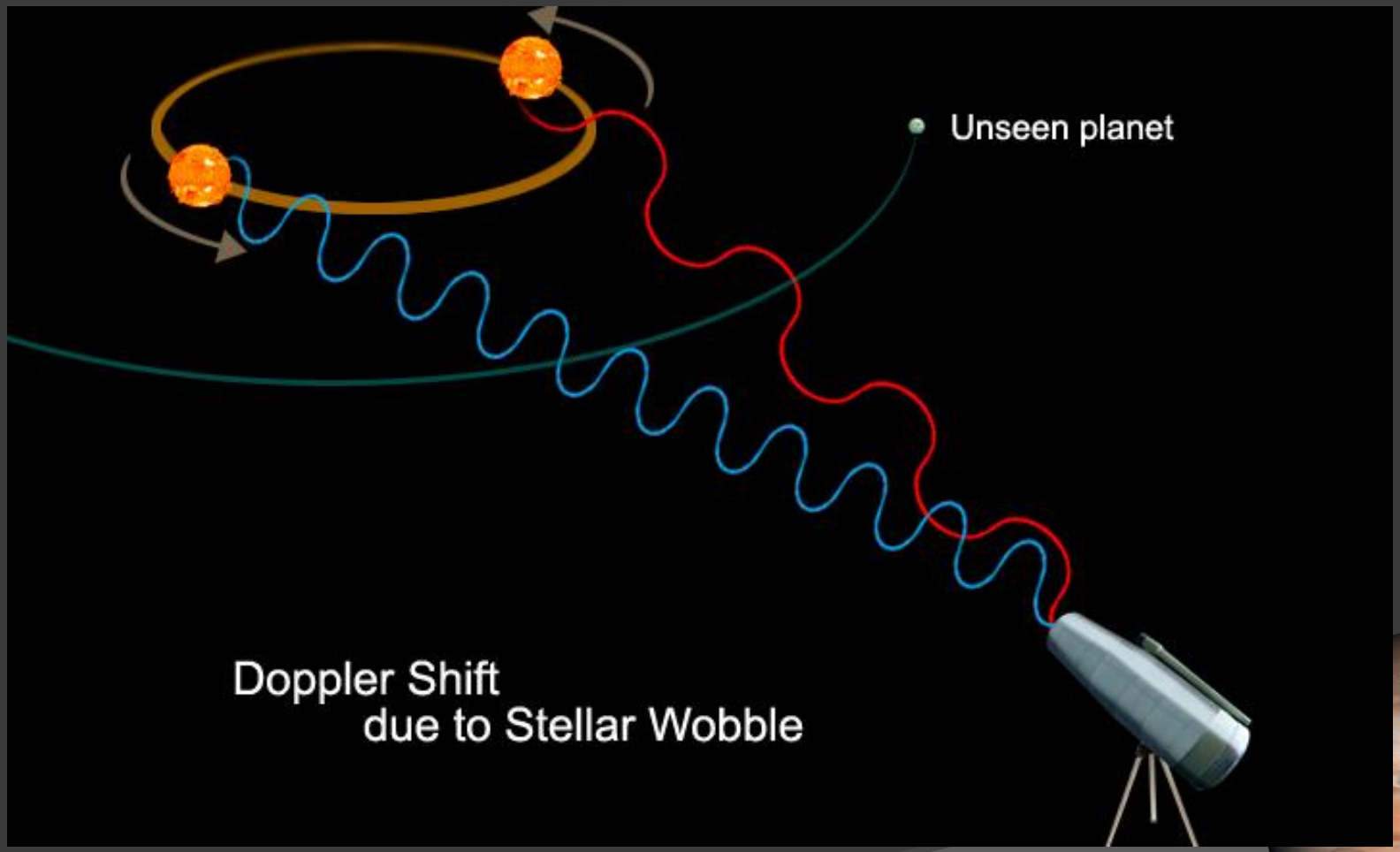
Radial VelocityMethod

- Newton's Third Law: action-reaction
  - Star pulls on planet
  - Planet pulls on star
- Less massive planet has greater acceleration (wide orbit)
- More massive star has less acceleration (small orbit)

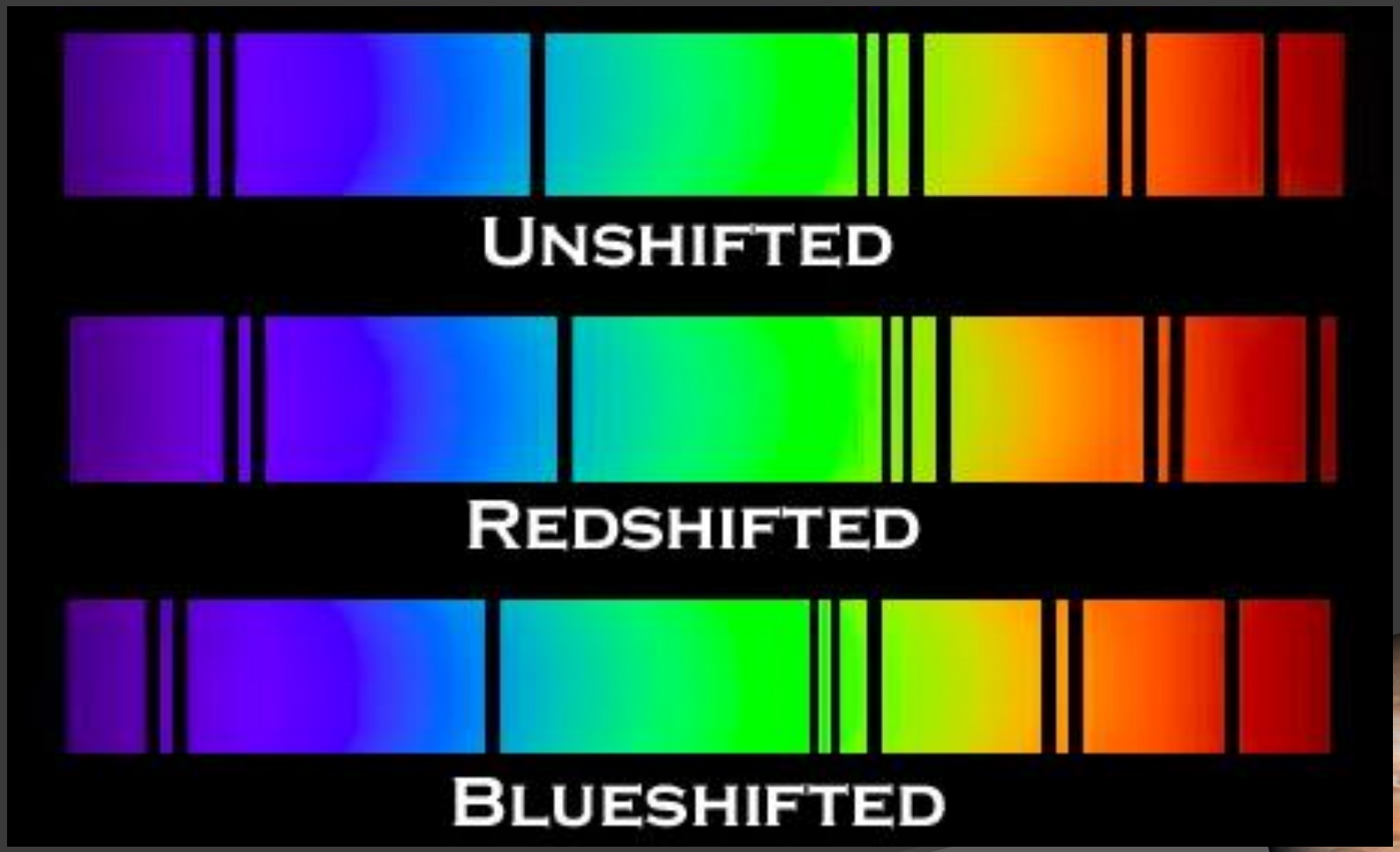
Orbital Motion



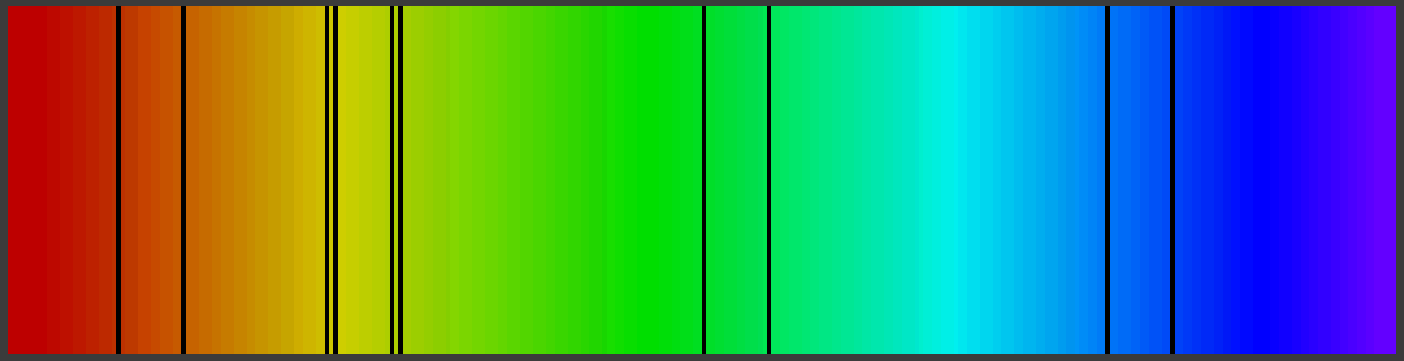
Radial Velocity Technique

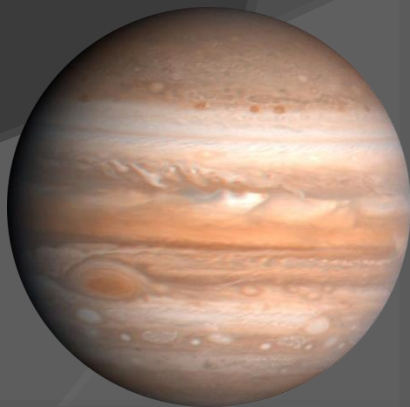


Radial Velocity Technique

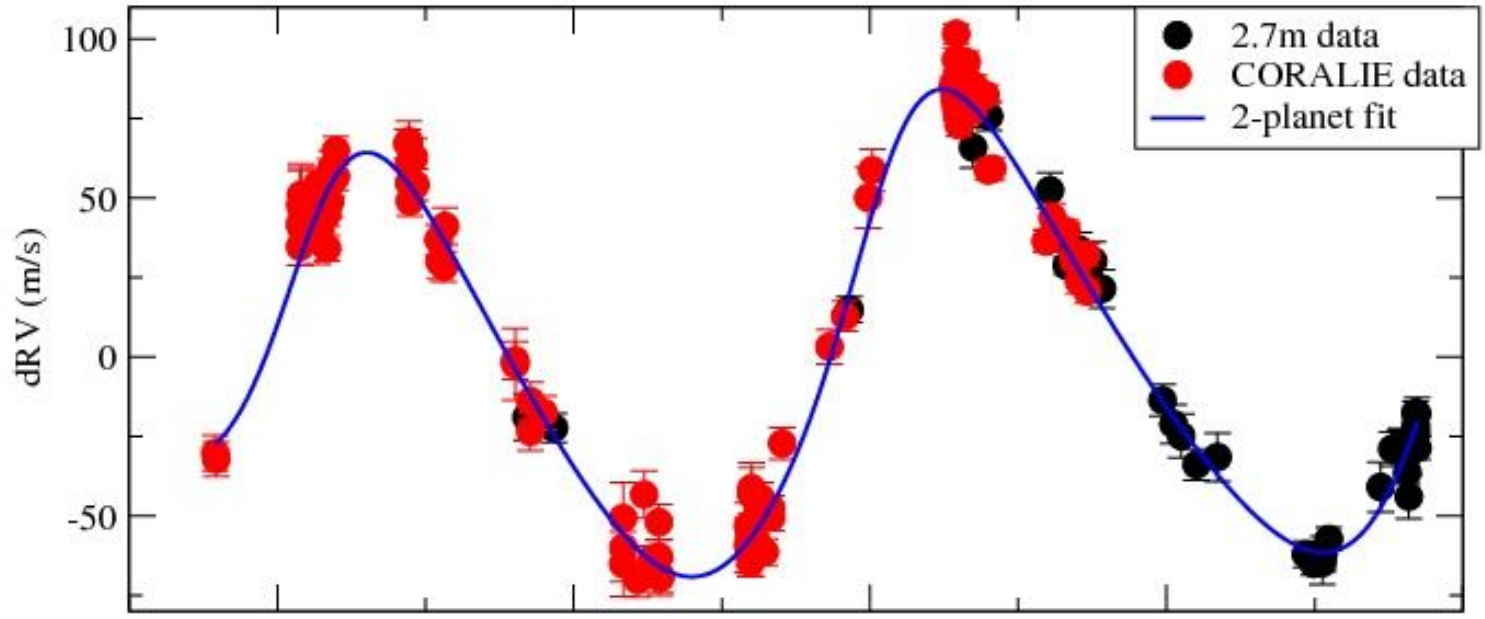


Radial Velocity Technique



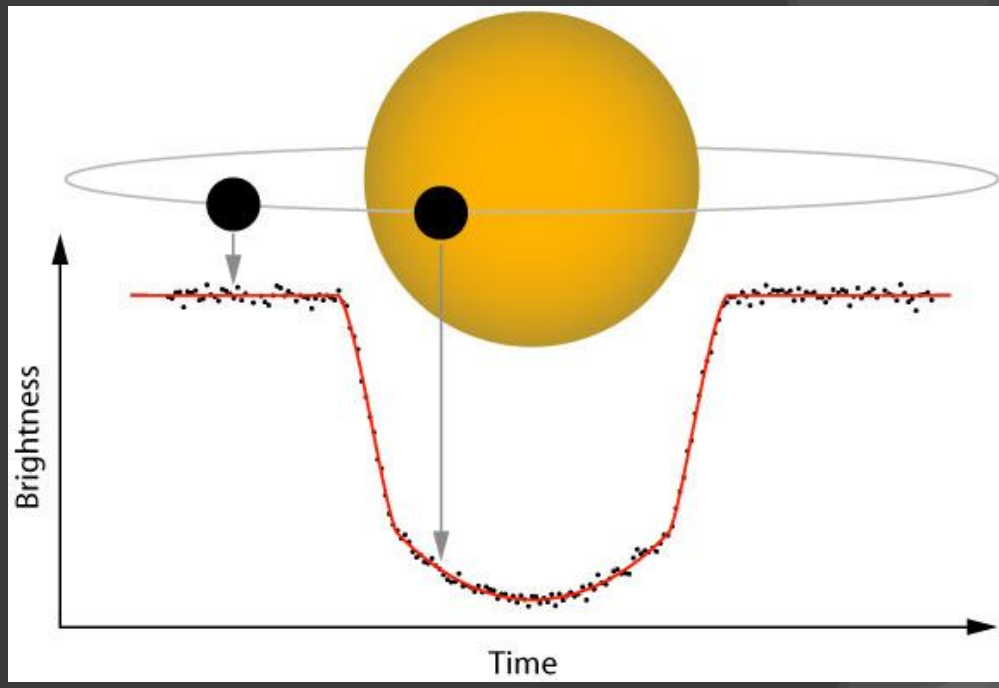


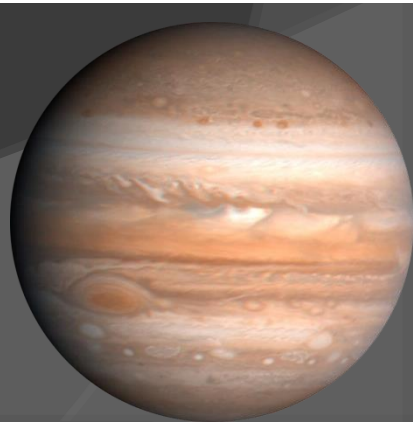
Radial Velocity Technique



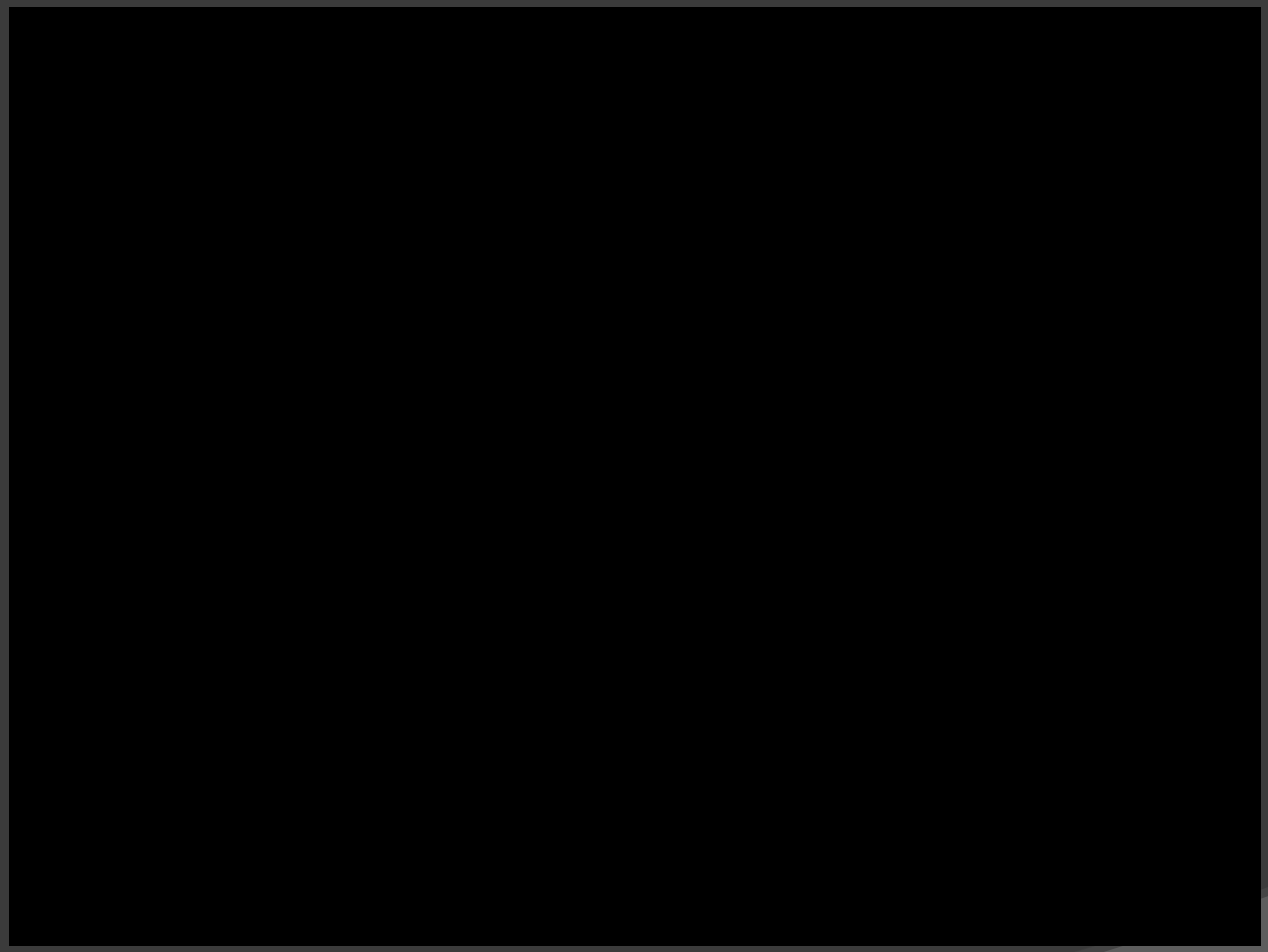
Eclipse/Transit Technique

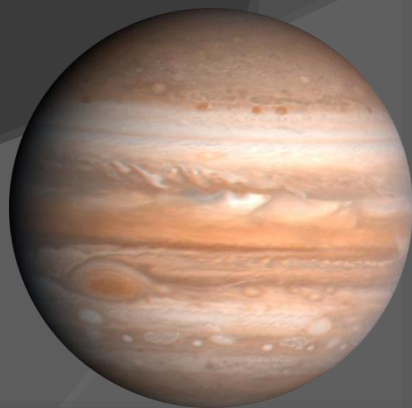
- Brightness drops when planet passes in front
- Need “lucky” geometry to see a transit, so watch many stars





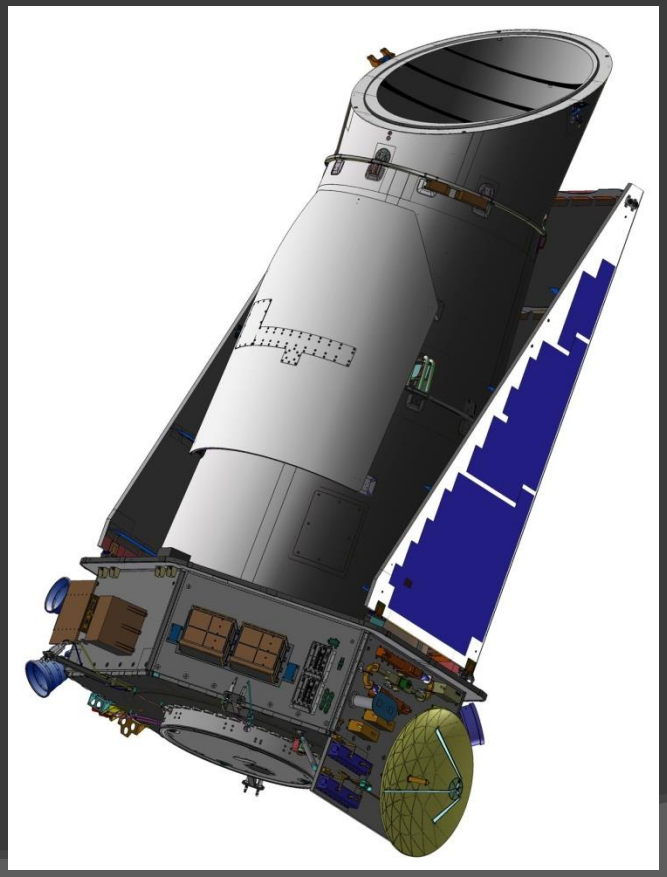
Eclipse/Transit Technique

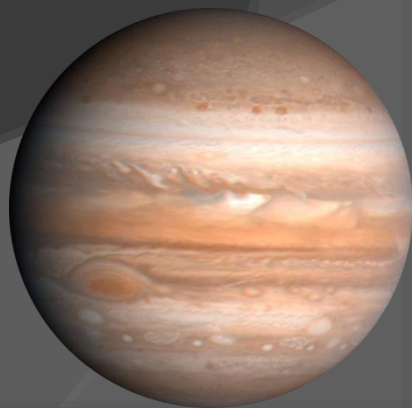




Eclipse/Transit Technique

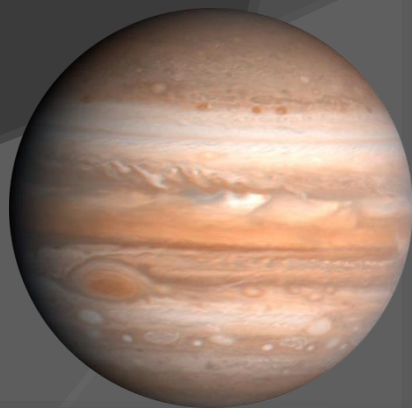
- *Kepler* NASA spacecraft



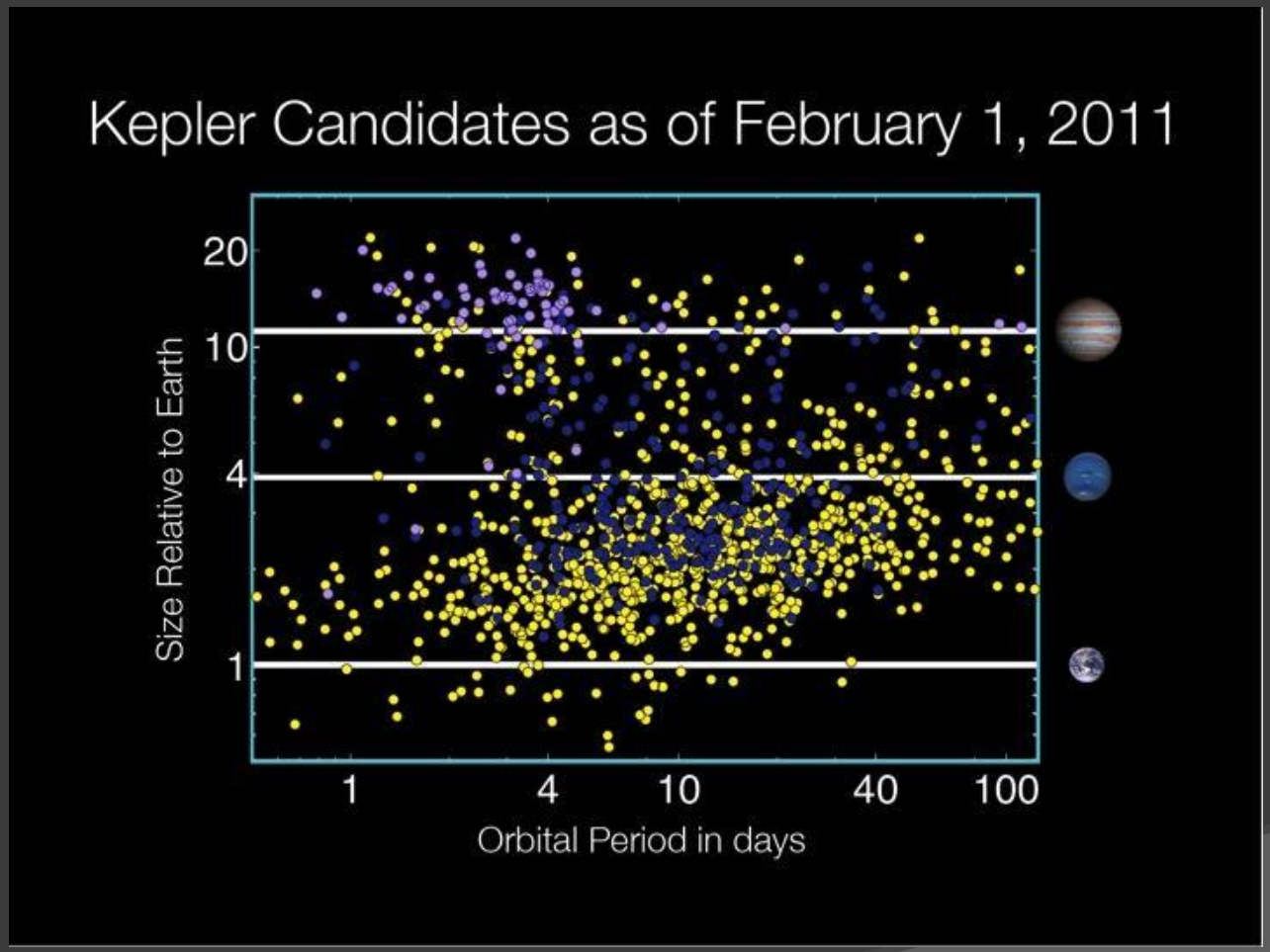


Eclipse/Transit Technique

- *Kepler* searches for *transits* of planets across the face of their parent stars
- Specifically designed to look for *potentially habitable Earth-size planets*
- Stares continuously at a couple hundred thousand stars
- Continuously monitors them for telltale dip in brightness (for ~4 years)

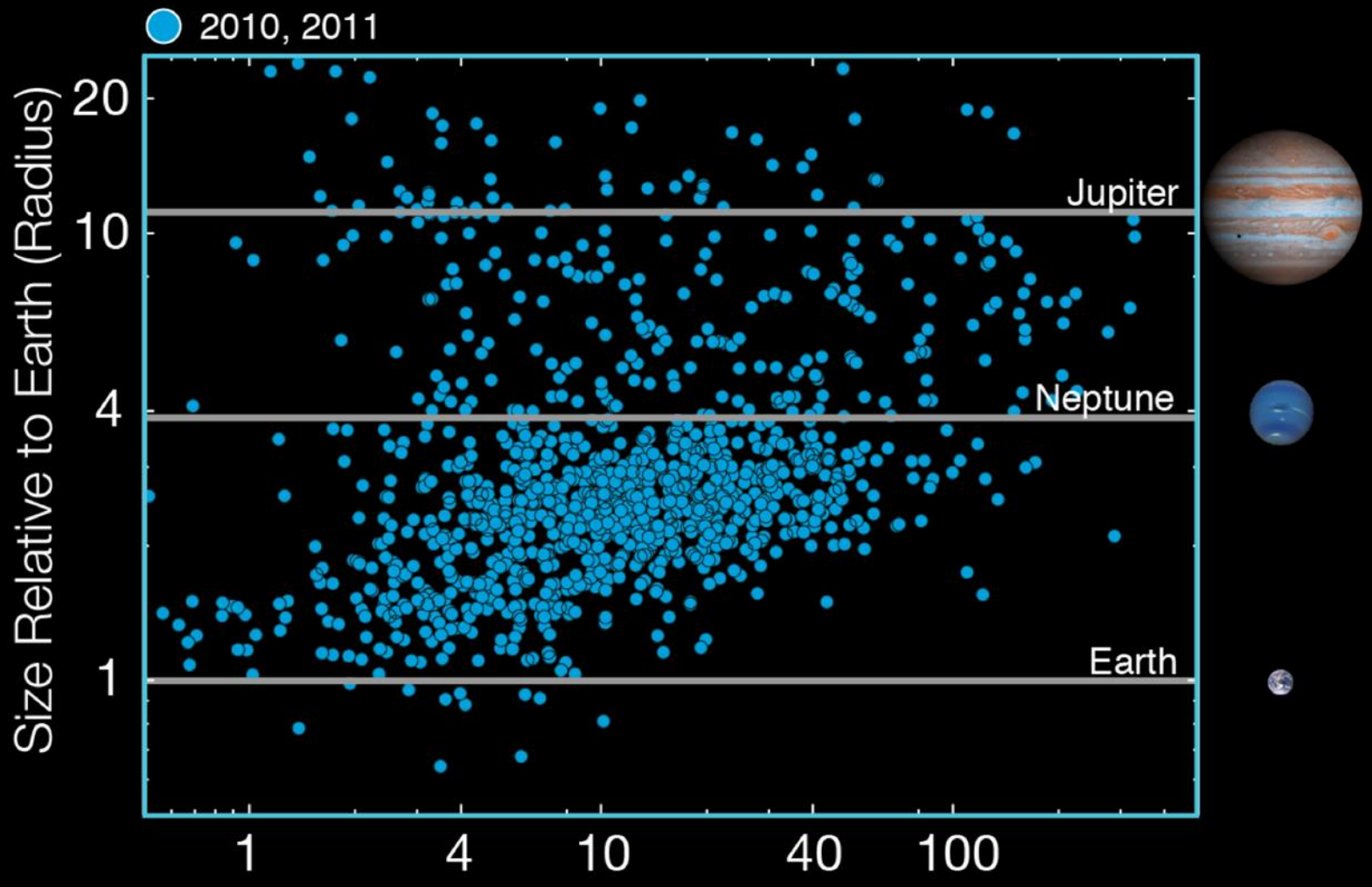


RV and Kepler Candidates



Planet Candidates

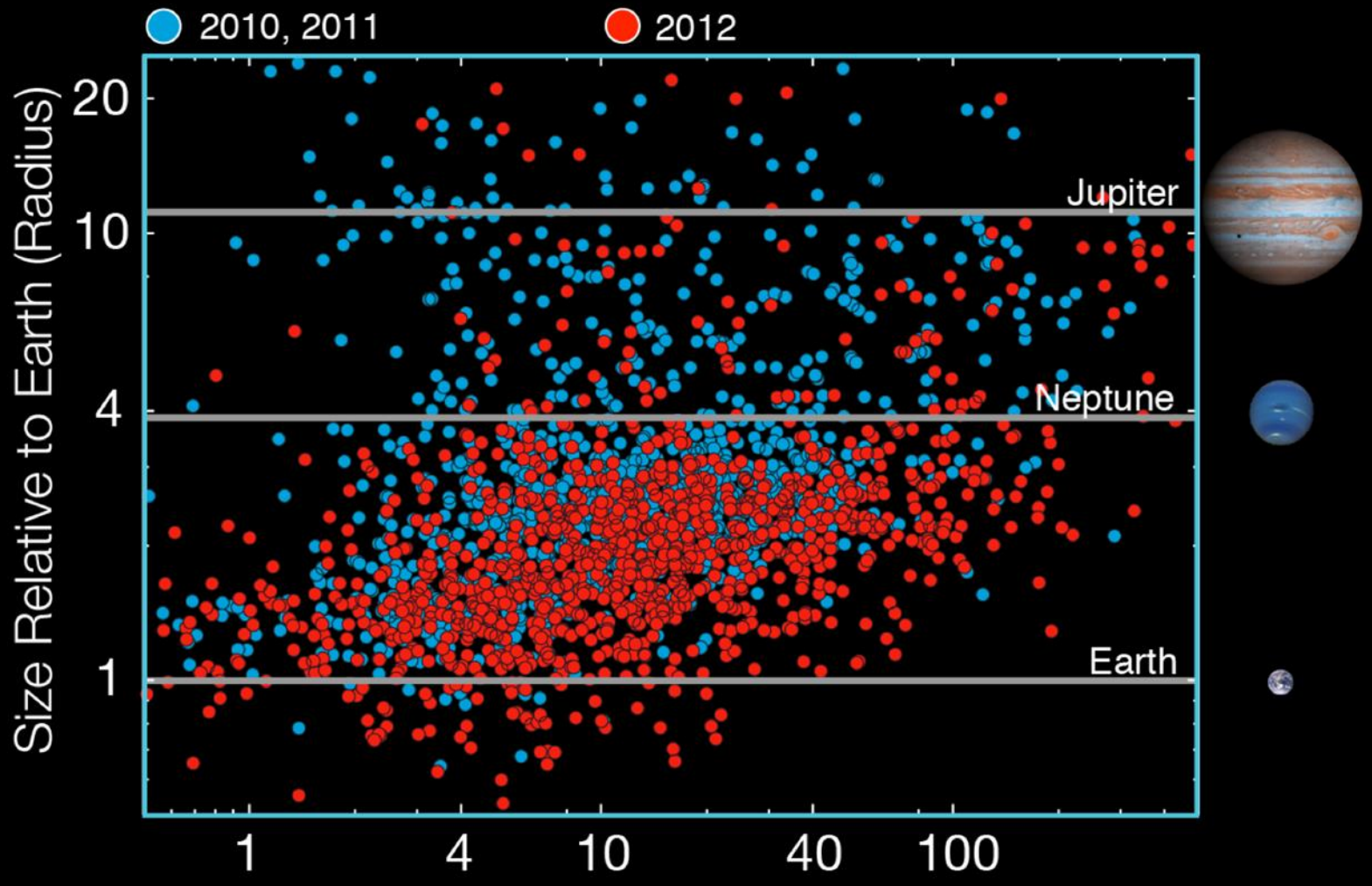
As of February 1, 2011



TOTAL = 1,235

Planet Candidates

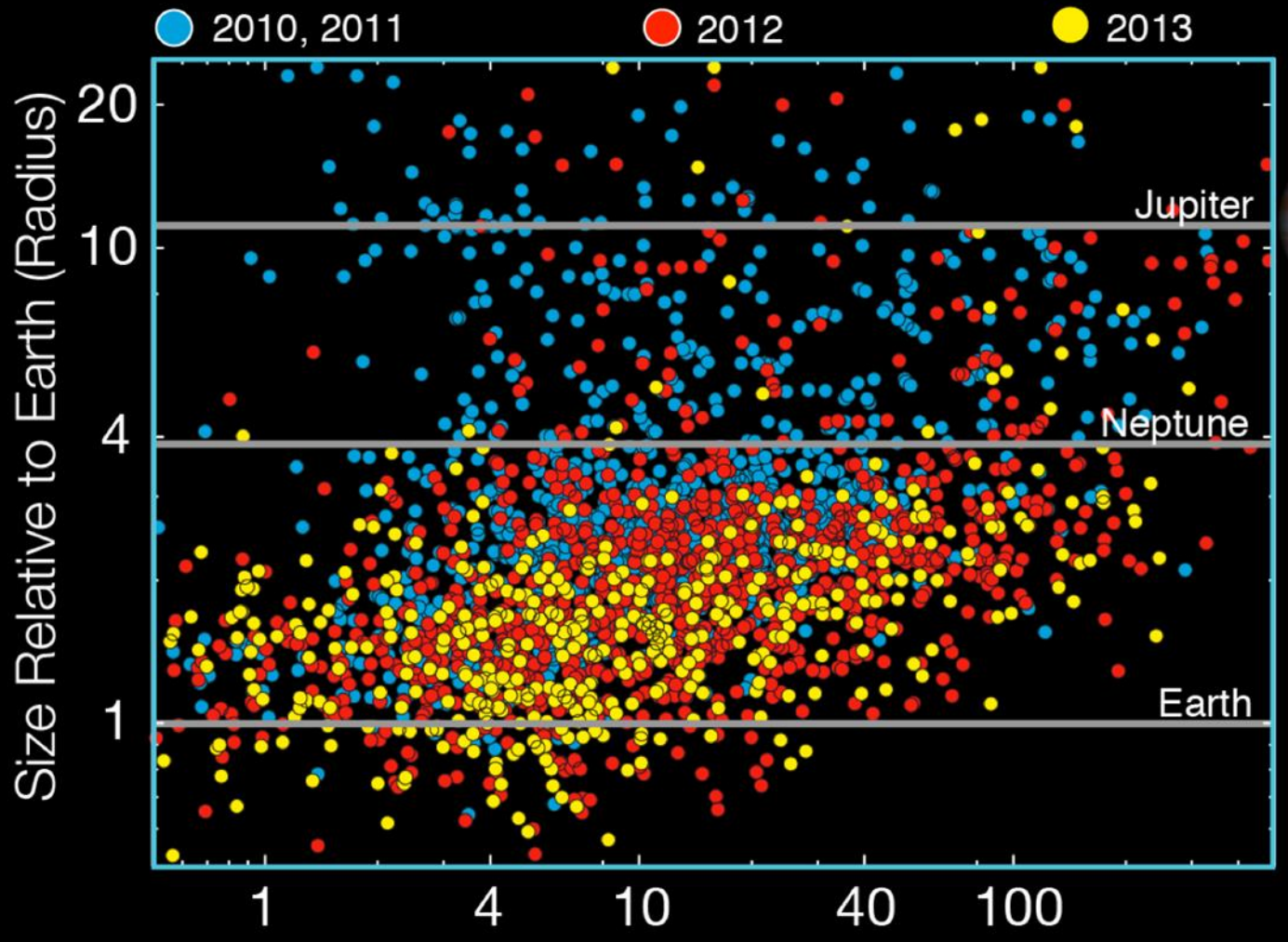
As of February 27, 2012



TOTAL = 2,321

Planet Candidates

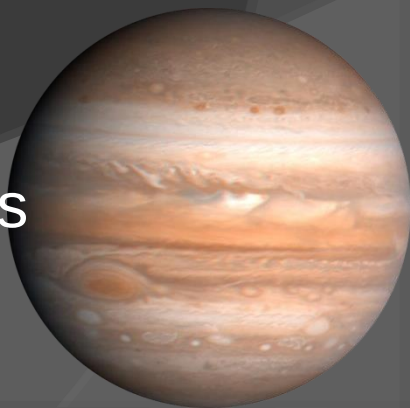
As of January 7, 2013



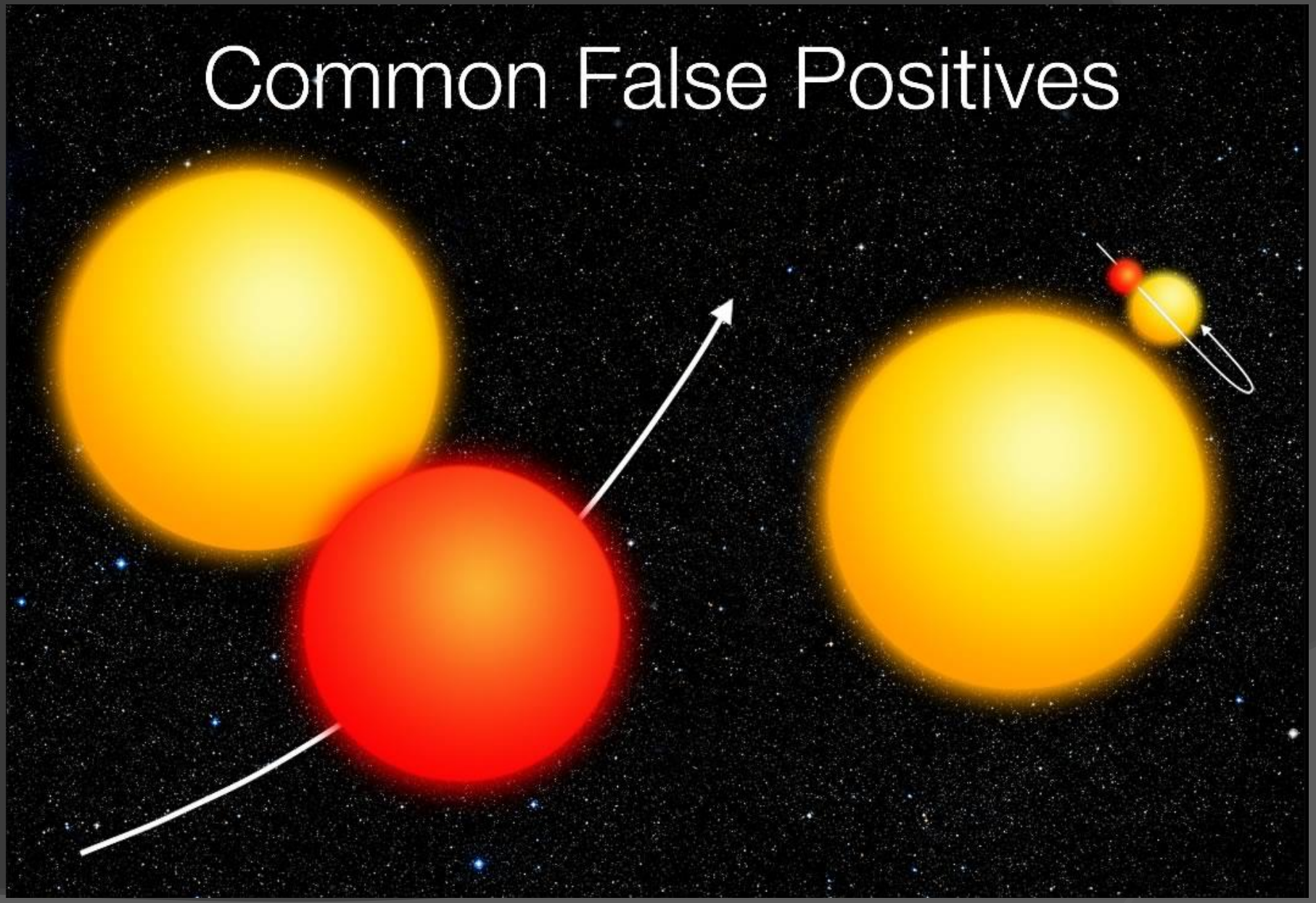
TOTAL = 2,740

Eclipse/Transit Technique

- *Kepler* Follow-Up Program: Going from candidates to real planets
  - Ground-based (including McD 2.7m and HET telescopes)
  - Characterize stars
    - Light curve gives *ratio* of star to planet radii
    - Need to know the star's size to get the planet's size
  - Used to rule out "false positives"
    - Binary stars → wild radial velocity changes

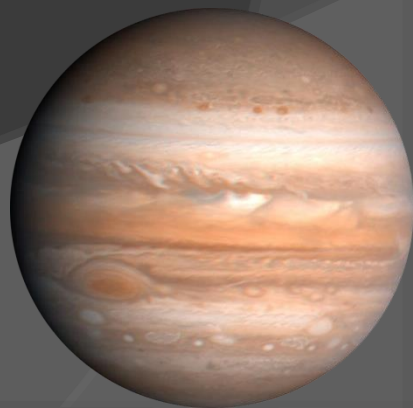


Common False Positives

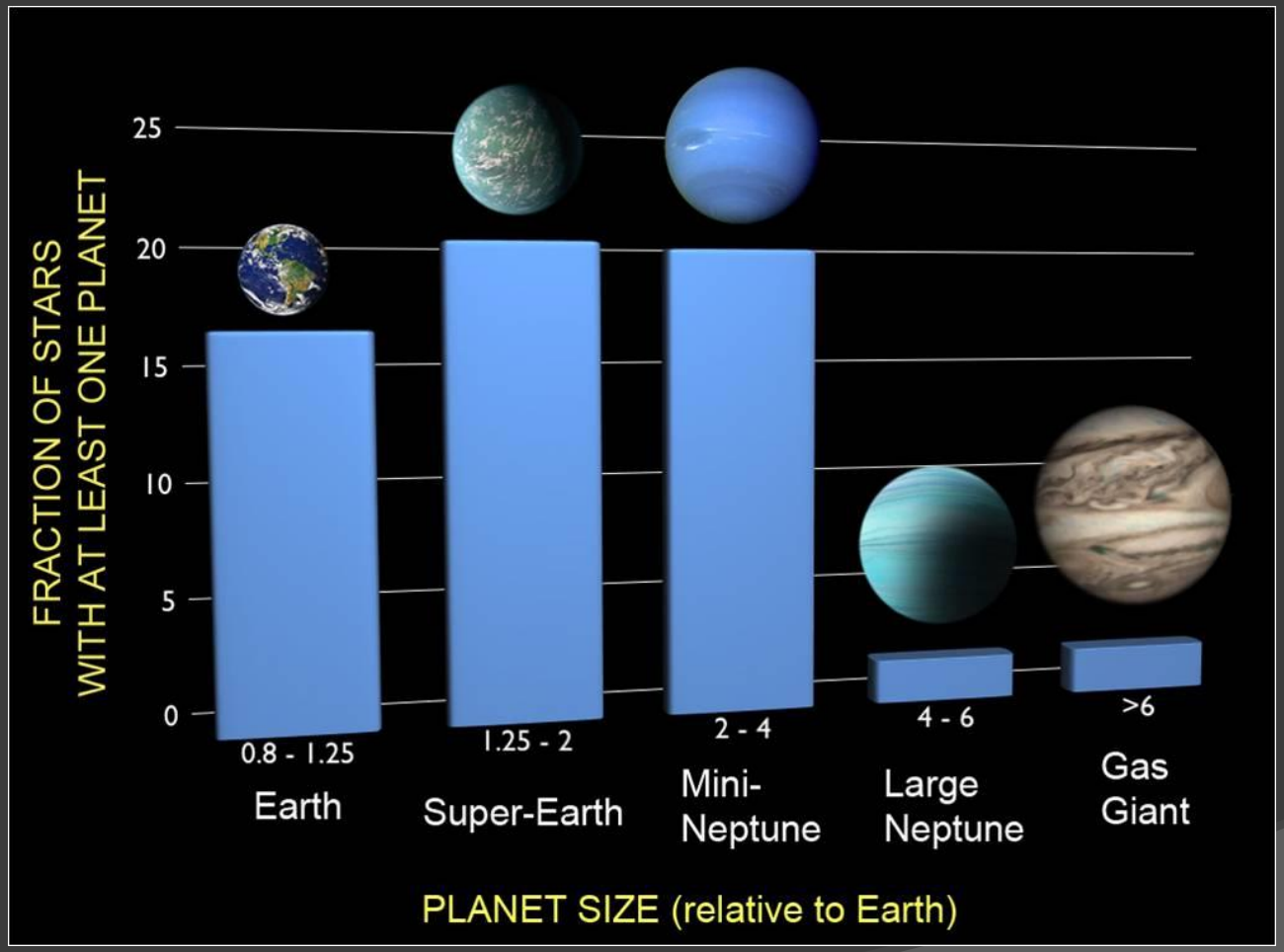


Exciting New Result #1

- Planets are *everywhere!*
  - Over 4,000 planet candidates from *Kepler*
  - Average star has between 1 and 2 planets, based on current detection limits
  - Smaller planets are more common
    - likely makes the above estimate a lower limit

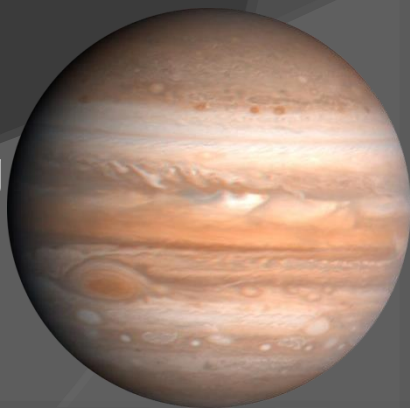


Planet Fractions (from candidates)

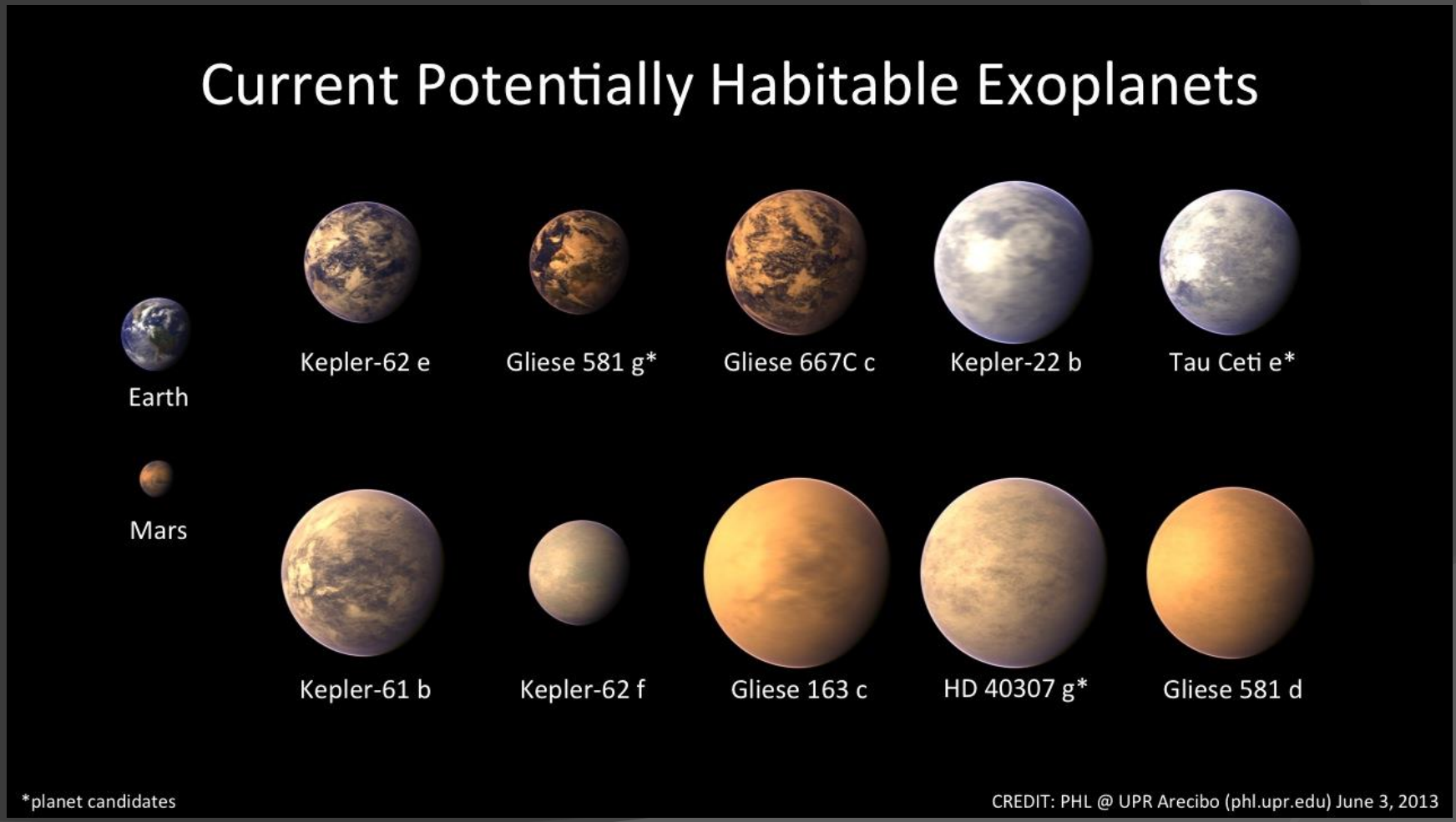


Exciting New Result #2

- Small planets in the “habitable zone”
  - Habitable zone: region around star where liquid water could exist
    - Not too hot (close to star)
    - Not too cold (far from star)
  - Kepler-62: five planet system
    - With two Earth-size (roughly) planets, in the habitable zone!
      - Smallest habitable zone planets yet discovered
      - Members of our team helped in discovery, using 2.7m telescope

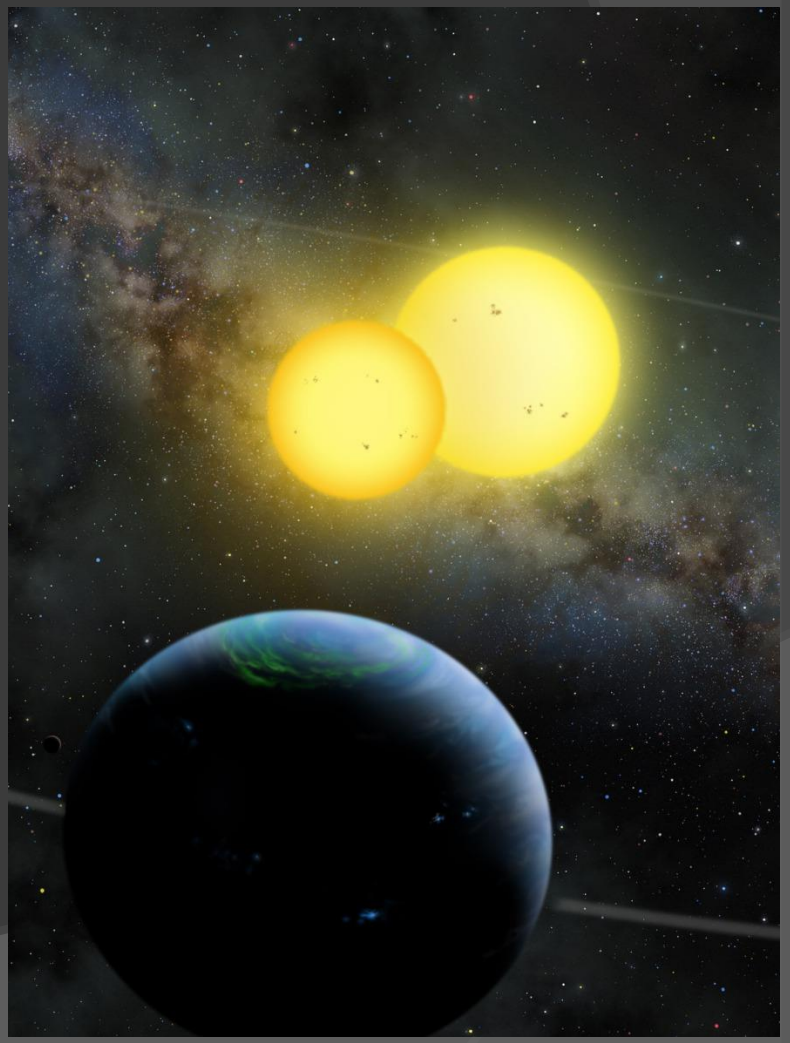


Most “Habitable” Planets



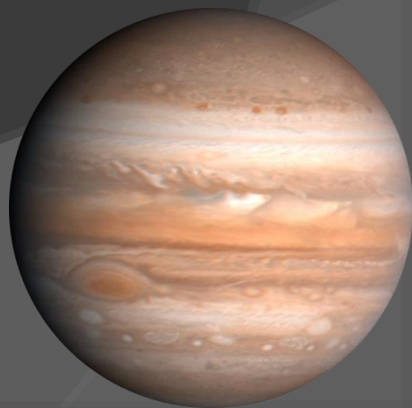
Exciting New Result #3

- "Tatooine Planets"
  - Planets orbiting a pair of stars (binary stars)
  - Planet formation around binary stars previously considered unfeasible
  - Now known to be much more common than originally thought!



Exciting New Result #4

- Planets next door!
  - Alpha Centauri: closest star system to the Sun (4 light-years away)
  - Earth-mass planet around Alpha Cen B (discovered in late 2012)



Conclusions

- *Kepler* has shown us that small planets like the Earth are everywhere!
- Many such planets are likely habitable
- As demonstrated by Alpha Cen Bb, such planets exist nearby
- Long-term: study planets themselves (composition)