- Nighttime observing has 2 more nights. Check the webpage.
- **1st exam is October 10th– Friday!**
- Justin will have an extra office hour Thursday (10/9) before exam– 4:00 to 5:00pm.
- I will have an extra office hour Wednesday (10/8) before exam– 10:30 to 11:30am.

Exam #1

- **Date:** Friday, Oct. 10th
- **Place and Time**: In class, at the normal 12:00-12:50pm time.
- **Format**: 40 multiple choice problems and 2 bonus questions (extra credit).
- **Bring:**
  - Yourself, well-rested and well-studied
  - A #2 pencil
  - On the test you will be given numbers or equations (if any) that you will need. You may **not** use your book or your class notes.

Exam #1

- **Topics included**: All material through Extra-solar planets. Lecture and reading material are both included. My goal is to test for understanding of the concepts we have discussed, and how they fit together.
- **Study tips.** We have covered a lot of material in a short time, so here are some tips on how to approach your studies for the exam.
  - Topics covered in lectures should be stressed.
  - Homework questions have good examples of questions that may show up on the exam. An excellent way to begin studying is to review the homework problems, particularly those you missed (or got right but were not so sure about). Be sure you understand what the right answer is, and more importantly, **why** it is right.
  - You will need to understand and be able to use any equations that have been introduced in class. Calculations using these equations will be kept simple--it is possible to do the exam without a calculator, but you can bring one if you wish.

Exam #1

- **In-Class Q and A:** On Wed., Oct. 8th, some time will be allotted in class to ask questions about material on the exam. For example, if there are homework answers you do not understand, this would be an excellent time to ask. To get the most out of this time, you are strongly encouraged to begin studying prior to this class.
- **Out of Class Q and A:** On Wednesday, Oct. 8th, I have office hours from 10:30 to 11:30am. On Thursday, Oct. 9th, Justin has TA office hours of 4:00 to 5:00pm. You should bring questions.

Outline

- Does the Solar Nebula theory work for other systems?
- Extrasolar planets

Test Of Exoplanets

Planets around other stars
= extrasolar planets = *"exoplanets"*

Hard to find!

Cannot just look at star
- planet lost in glare

Can use Newton's laws
- Newton 3rd Law: star pulls on planet,
- but planet pulls on star with equal & opposite force
- planet lighter, moves faster
- but star must move too!

Star Wobble

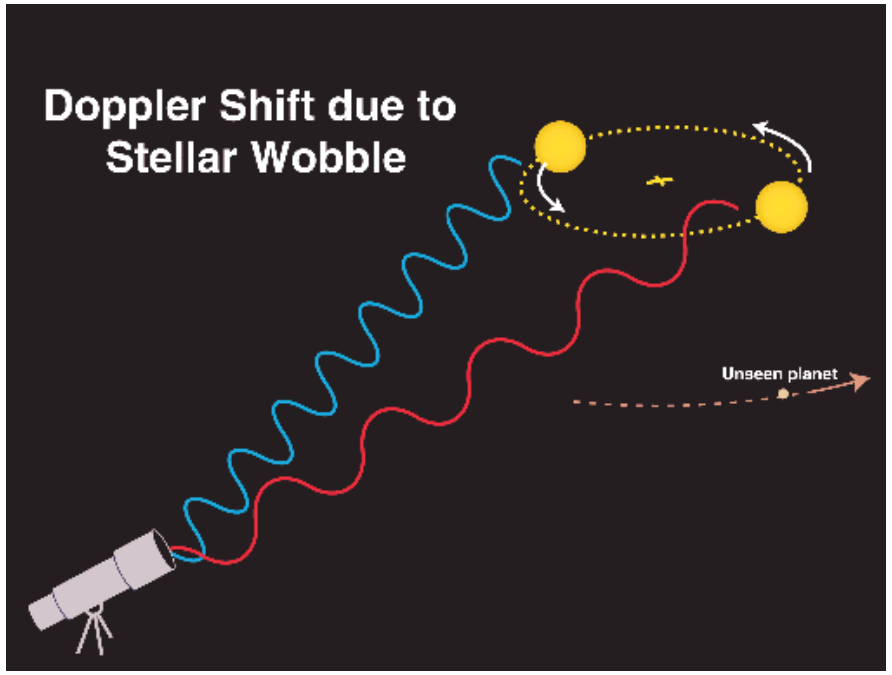
Newton's 3rd Law:

- *both* planet *and star* move
- both orbit fixed "center of gravity"

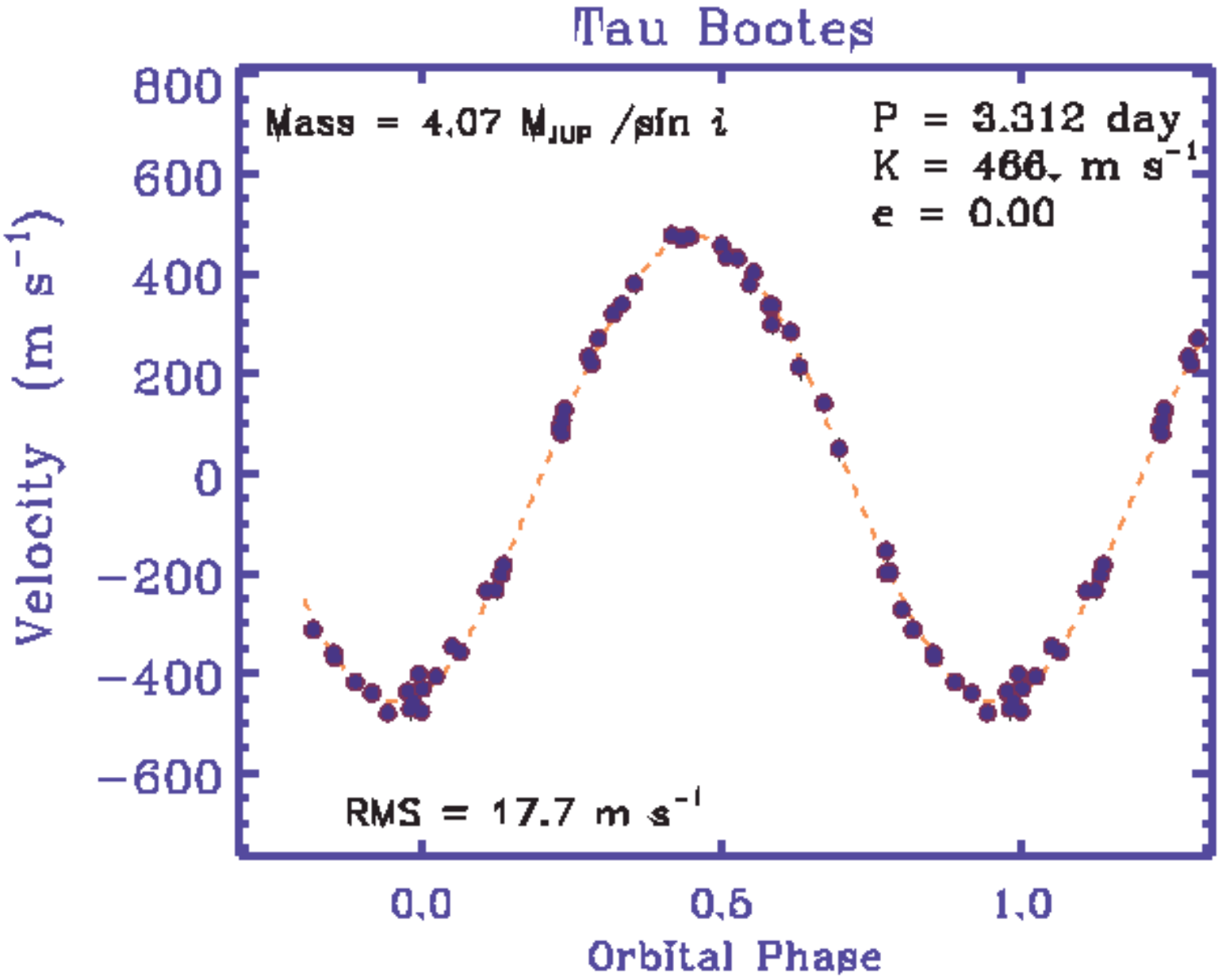
http://www.howstuffworks.com/planet-hunting2.htm

- Star's period? Place your bets…
  same as planet

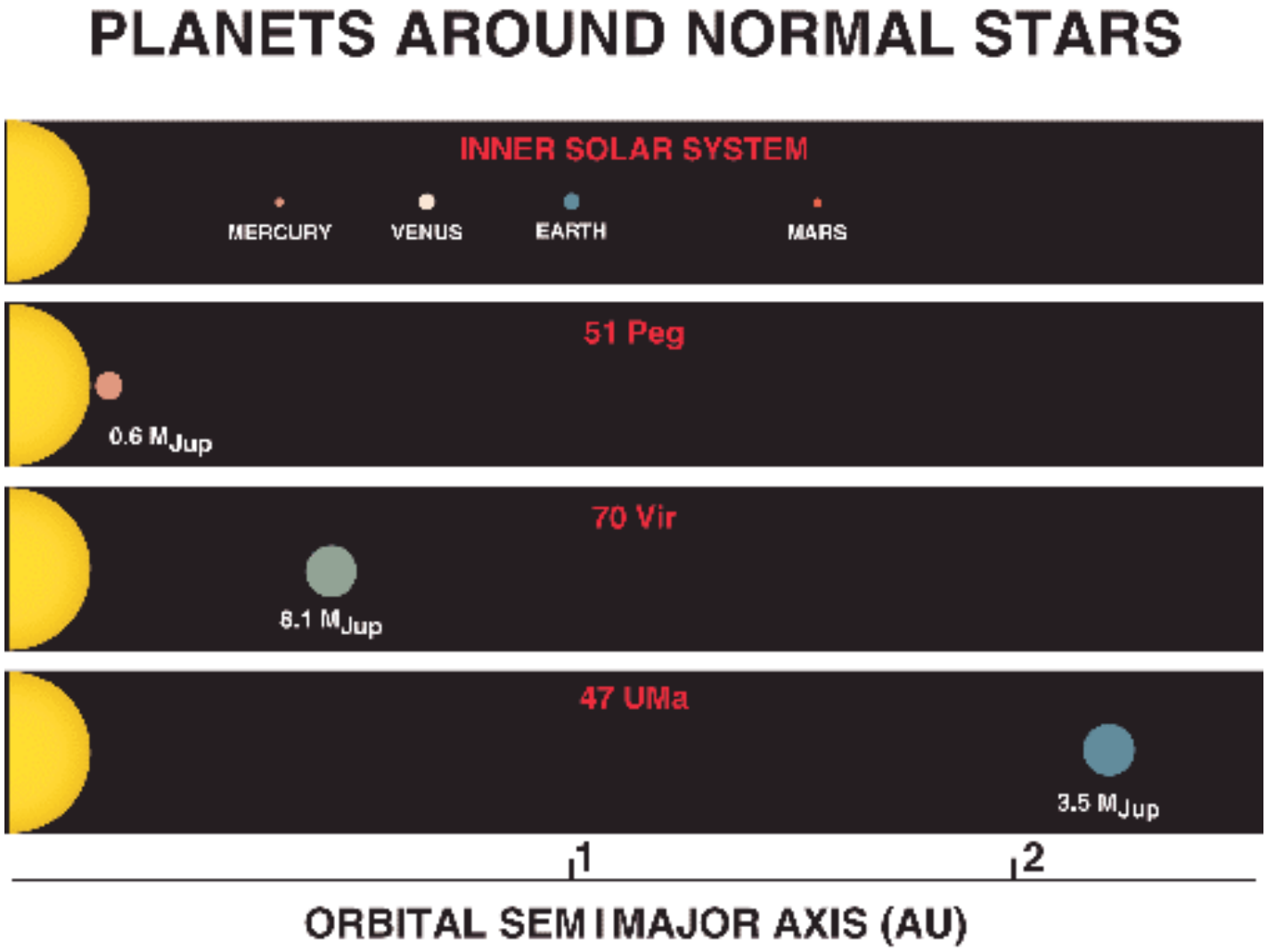
- star movement too small to see
  - moves in small, tight circle
  - but "wobble" in star speed detected!



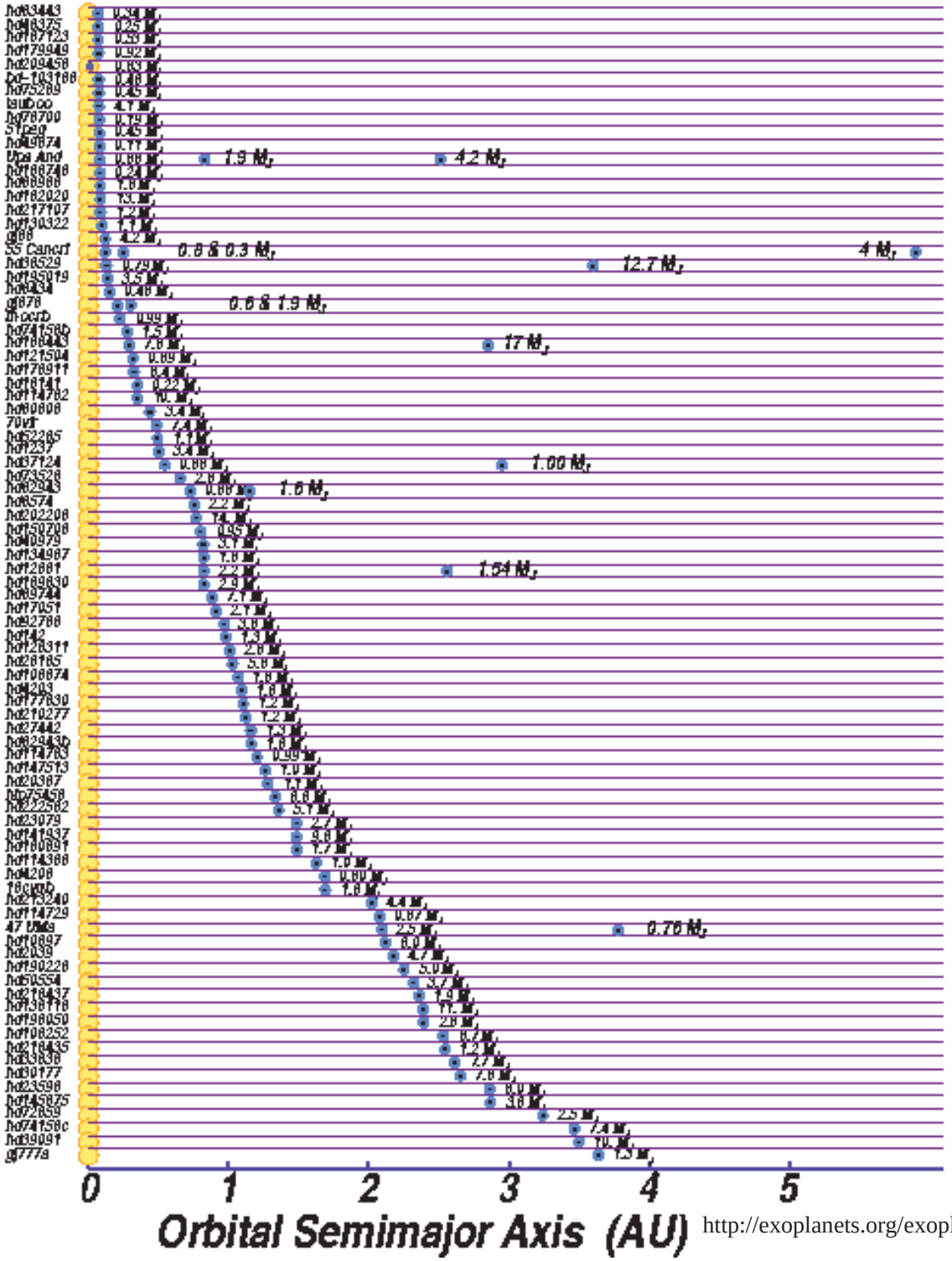
Planets around other Stars?



Early Discovery-- 1996



As of this month, there are at least 110 Planets around other nearby Stars.



http://exoplanets.org/exoplanets_pub.html

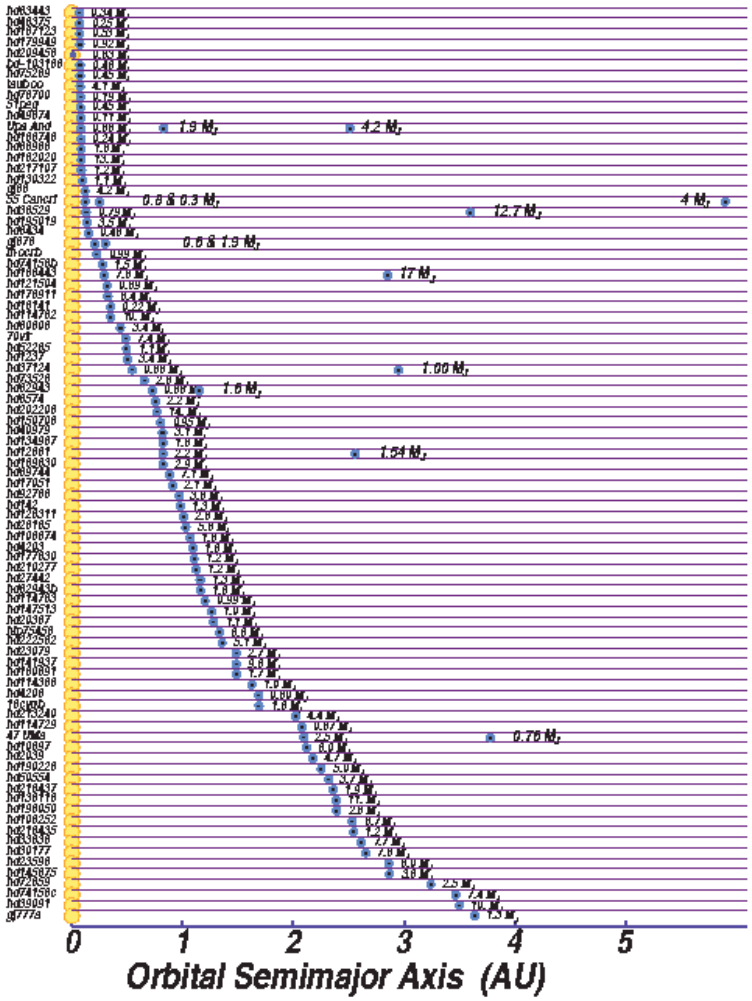
Exoplanets: *Results to Date*

- Over 110 planets detected so far
  - More than 10 times the number in our Solar System!

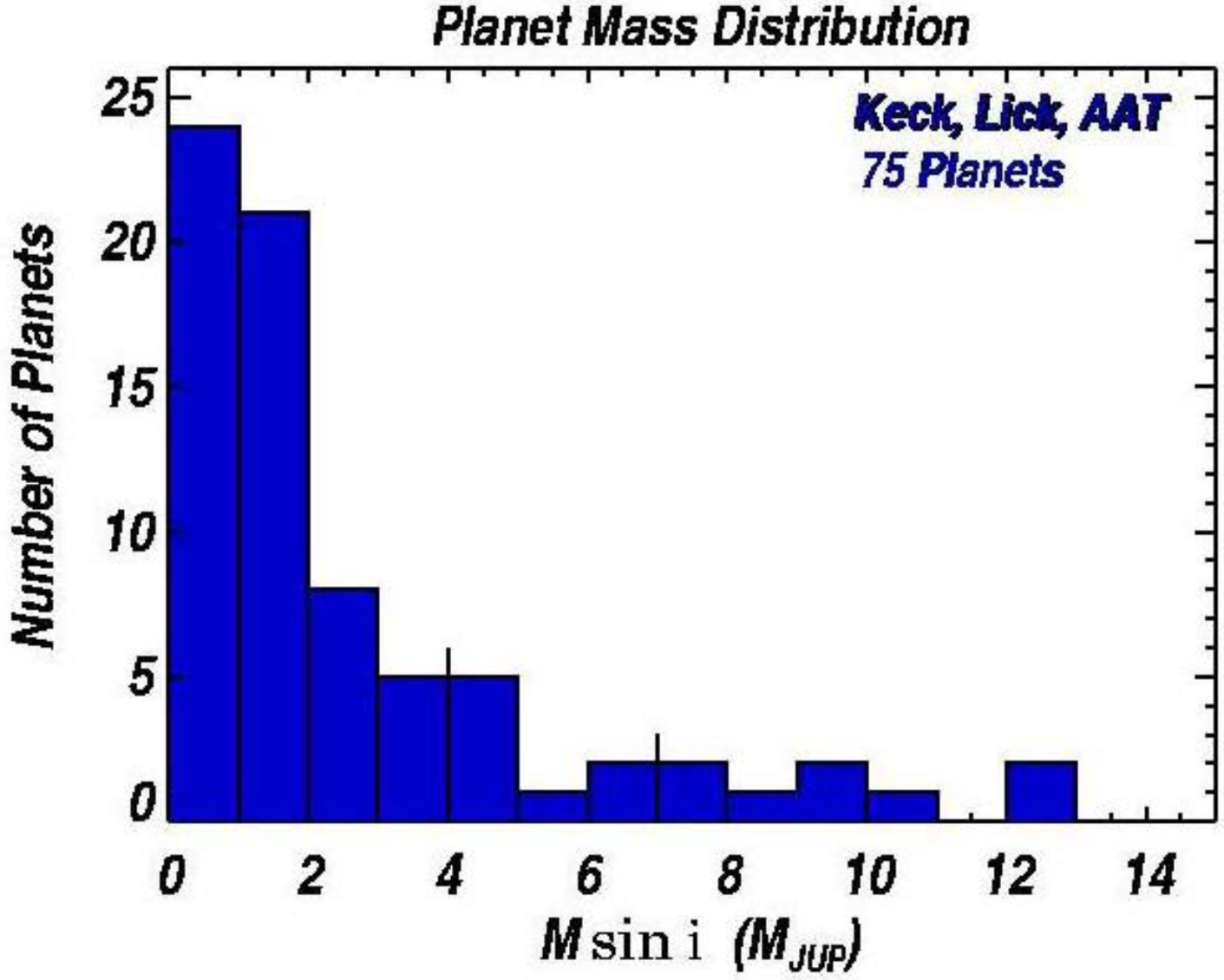
- measure $P_{star} = P_{planet}$

  Kepler, Newton:
  - planet distance $P^2 = a^3$
  - Note: get distance w/o directly measuring it!

- wobble speed gives planet mass

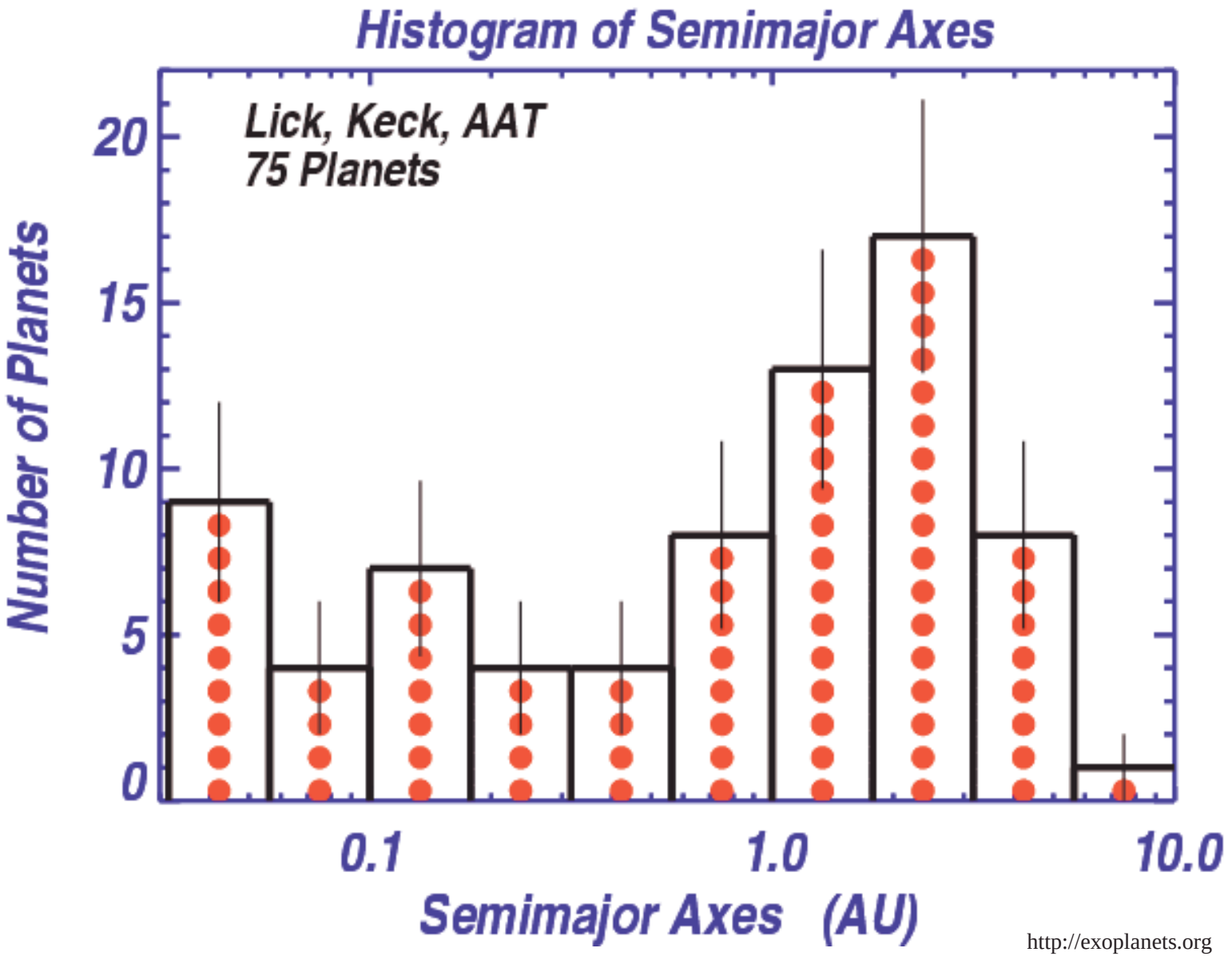


Masses



http://exoplanets.org

Semi-Major Axes



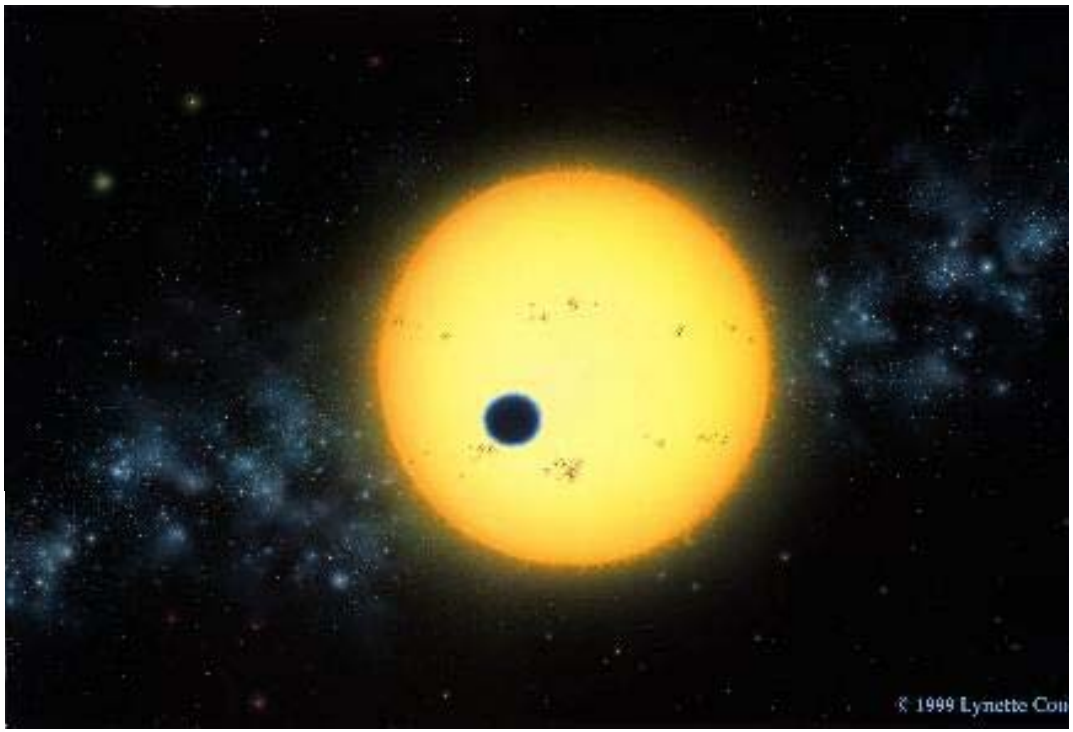
http://exoplanets.org

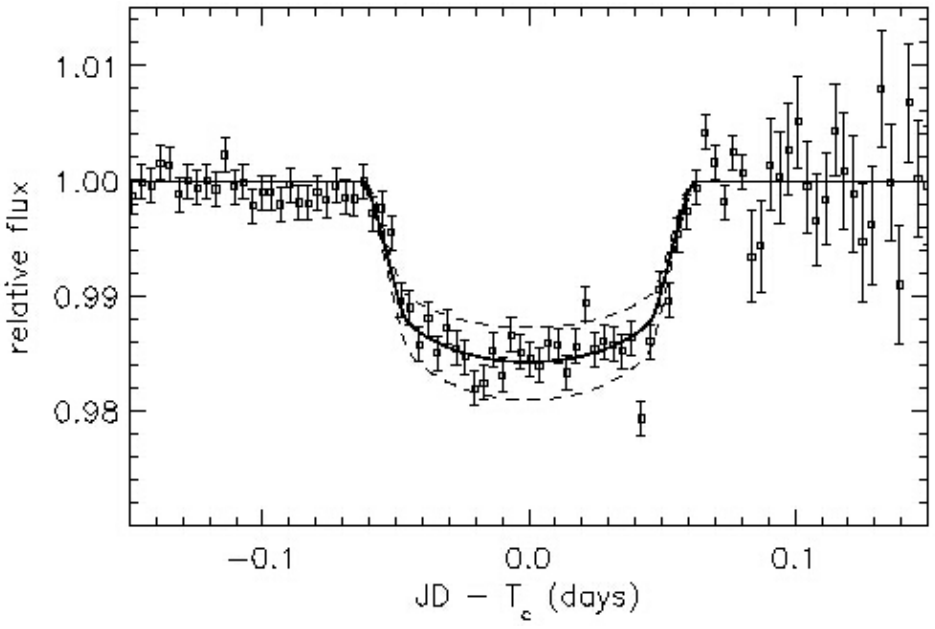
List

http://exoplanets.org/planet_table.shtml

And Transits of Some

- What if the detected planet transits the star?
- http://www.howstuffworks.com/planet-hunting2.htm
- A few solid detections.





http://www.hao.ucar.edu/public/research/stare/stare.html

Other Planets, Other Stars

47 Ursae Majoris System– 51 light years away (near the Big Dipper). 13 years of data has shown 2 planets– 1 Jupiter like and 1 Saturn like.

Wow!

Exoplanets: *Results to Date*

No Surprise:

- ✓ New planets are massive
- ✓ Why? needed to get big wobble
- ✓ If not massive, we could not have found them

Big Surprise:

- ? Period of few days--whip around stars
- ? Most planets are very near stars!
- ? Example: tau Boo is 3.6 x Jupiter mass,
  but closer than Mercury's orbit!

What Are We Looking For?

General Predictions of Solar Nebula Theory

- ☺ Are interstellar dust clouds common? ***Yes!***
- ☺ Do young stars have disks? ***Yes!***
- ? Are the smaller planets near the star?

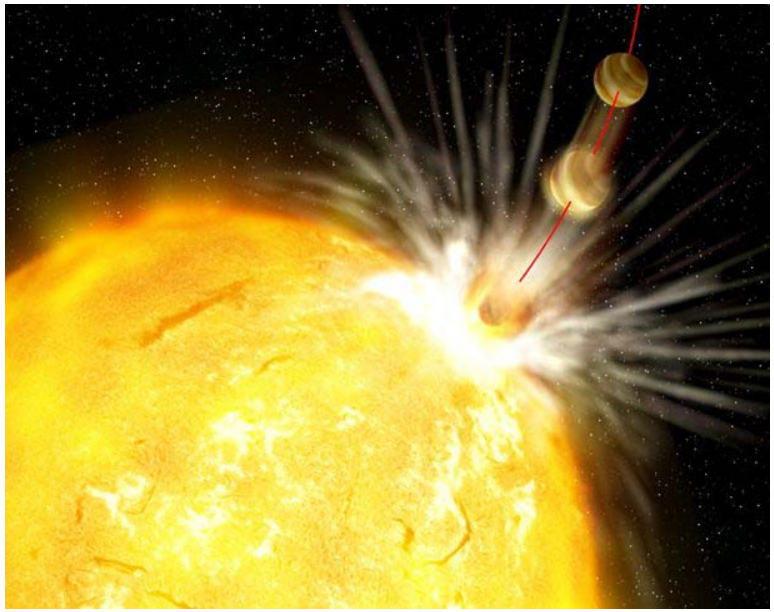
  Not the ones found so far!
- ? Are massive planets farther away?

  Not most of the ones found so far!

Exoplanets: Implications

Solar Nebula **Theory**:

- giant planets born far from star



Exoplanet Data:

- Giant planets found very close

Theory is *incomplete/wrong*!

New questions:

? Who is normal: them or us?

? Are giant planets born close in?

? Are some giant planets born far out, move in?
"planet swallowing"!?!

Anyway: planets common.

✓ good news in search for life elsewhere...

Review

- Celestial Sphere
  - Compare diurnal motion on NP, SP, and equator
- Seasons
  - What causes them– compare Uranus to Earth
- Phases of the Moon
  - What causes them? Rise and set times. How do they relate to the lunar day? What is the phase now?
- Eclipses
  - What causes solar and lunar eclipses? What's the difference?

Review

- Solar System Overview
  - Geocentric and Heliocentric
  - Ptolemy, Copernicus, Brahe, Kepler, Galileo, Newton
- Kepler's 3 Laws
- Galileo
- Newton's 3 Laws and Universal Law of Gravity
- The Solar System
  - The Earth and Moon
  - The Terrestrial Planets
  - Jovian Planets
  - Asteroids
  - Kuiper Belt
  - Oort Cloud

Review

- Solar System Formation
  - Solar Nebula Theory
  - Planet formation
- Extrasolar planets