Detecting Extrasolar Planets

12/2/2009

Opening Discussion

- http://www.youtube.com/watch?v=fvQJEXfIDCo
- Have you seen anything interesting in the news?
- http://www.youtube.com/watch?v=VHH8cXM4_n4
- Schedule change.
- What did we talk about last class?

The Challenge

- Finding planets is hard. Think of our scale model for the Solar System.
- Finding another Earth is like trying to see a marble or a grain of sand a few meters from a grapefruit in Alaska.
- To make matters worse, the grapefruit is glowing brightly while the smaller objects only reflect the grapefruit's light.

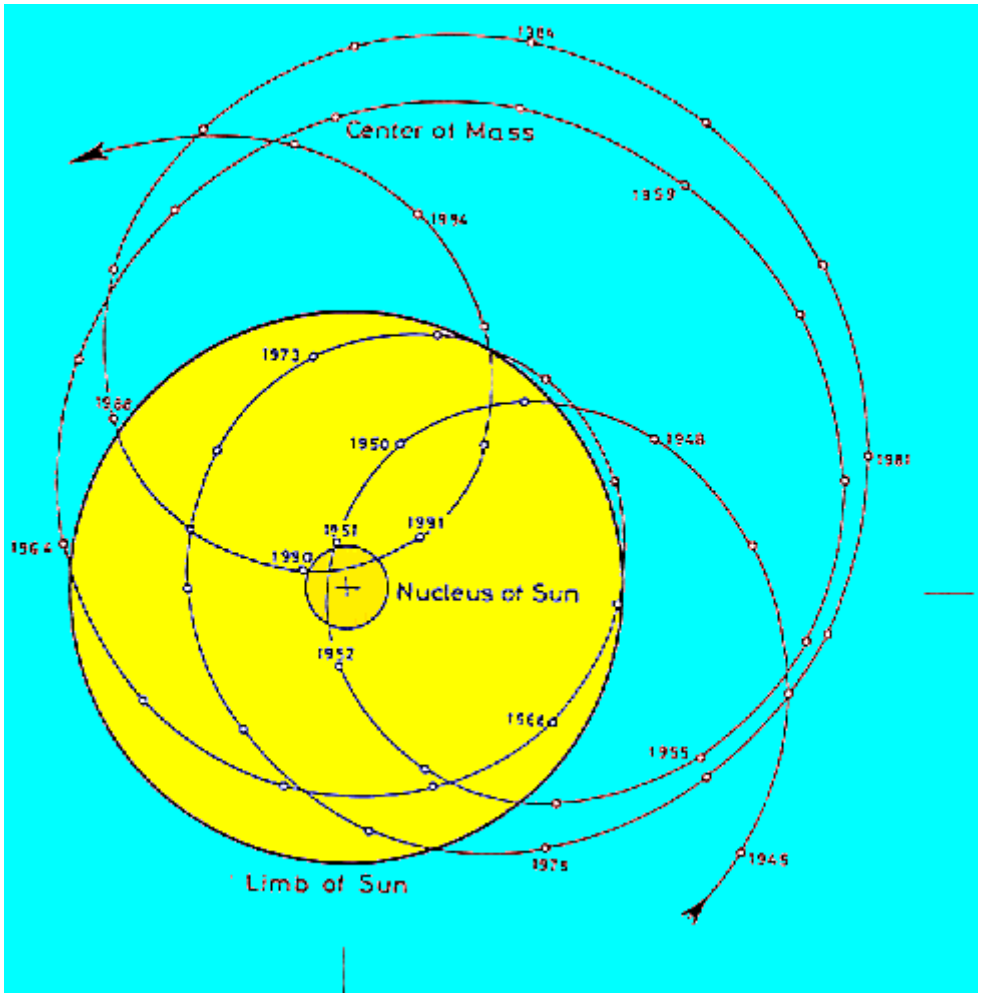
Direct vs. Indirect

- The ideal way to detect planets is to take images of them. This is direct detection and we are only just capable of doing it for a few specific types systems.
- Most planets have been detected indirectly by analyzing star light and looking for signs that a planet is present.

Wobbling Stars

- The first two indirect methods rely on the fact that planets and stars both orbit around there center of mass.
- Instead of looking for the planets, they look for the motion of the star as the planets move around it.

Path of our Sun



Astrometry

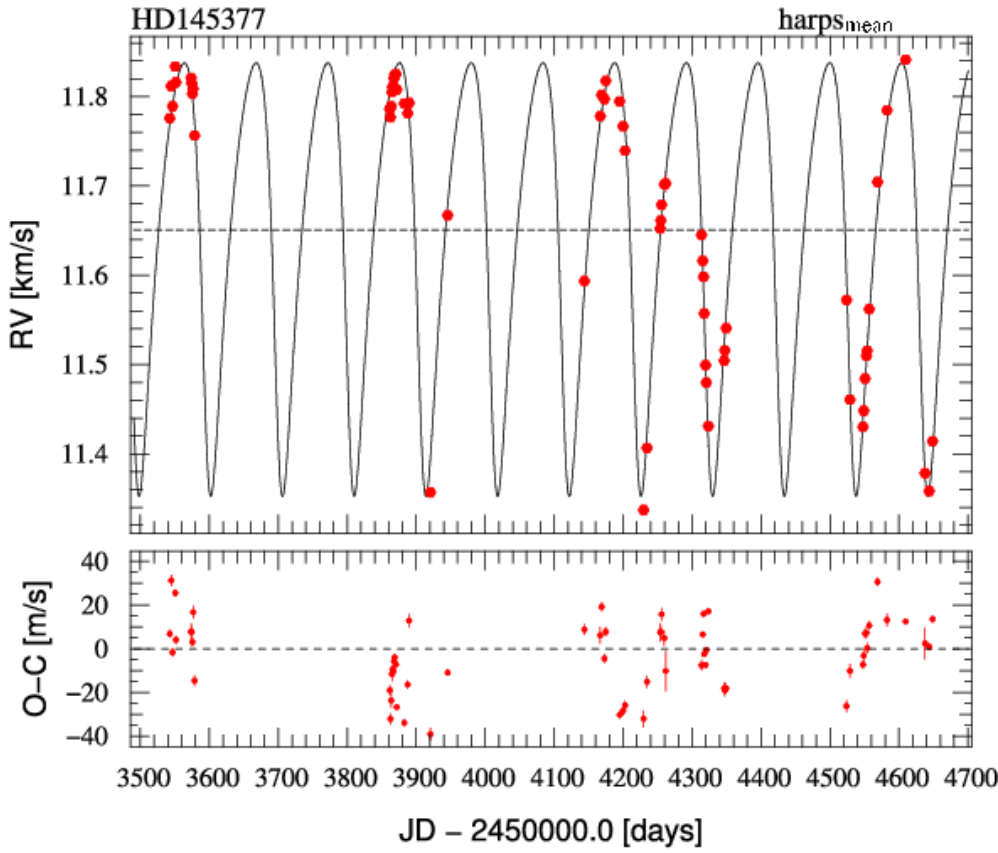
- The more straightforward method is to measure the position of the star very accurately.
- At a distance of 10 ly Jupiter's effect on our Sun would be a movement of 0.003 arcseconds.
- This method is only beginning to become useful.
- Favors large planets further from their star. Requires long periods of time.

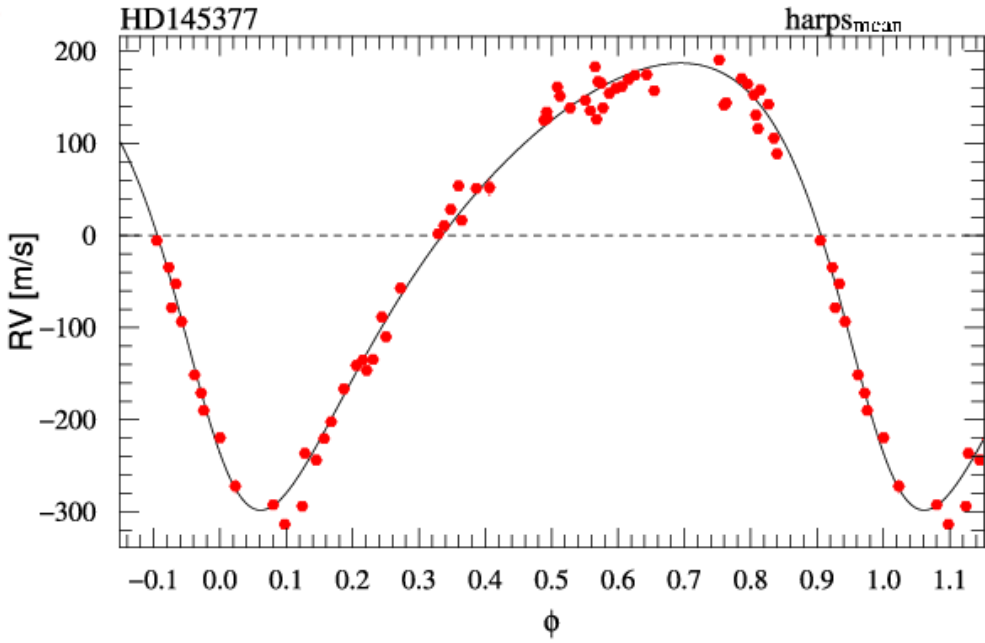
Radial Velocity

- Unless the orbit is perpendicular to us, some of the stars motion will be toward us and away from us.
- Radial velocity searches measure Doppler shifts to find small changes in the velocity of a star. Currently accurate to 1 m/s.
- Most known extrasolar planets have been discovered this way.
- Favors large planets that are close in. Measures lower bound on mass.

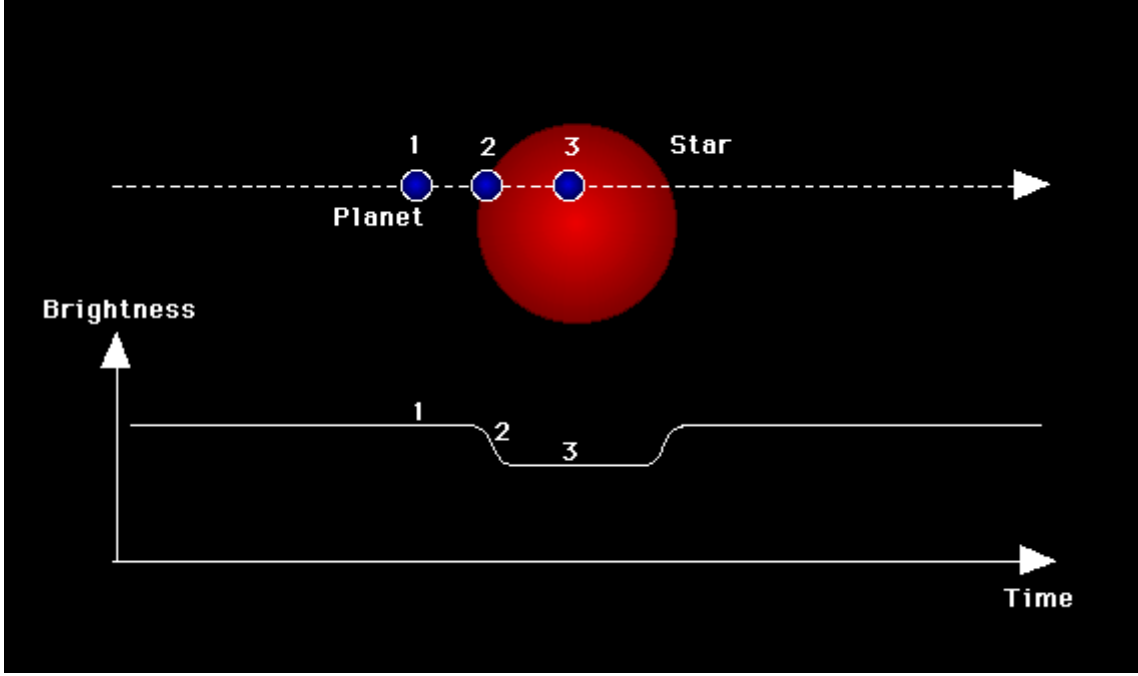
Radial Velocity Data

- You can find period of the planet which, given the mass of the star, gives you semimajor axis.
- Amplitude provides lower bound on mass of the planet.
- Shape gives eccentricity.





Transits Photometry



- Another indirect method is to use photometry and look for planet transits.
- A transit is when the planet passes between us and the star. It will temporarily block some of the light from the star. If this is seen to happen periodically, we know it is a planet.
- Gives size data. Only works if system is edge on.

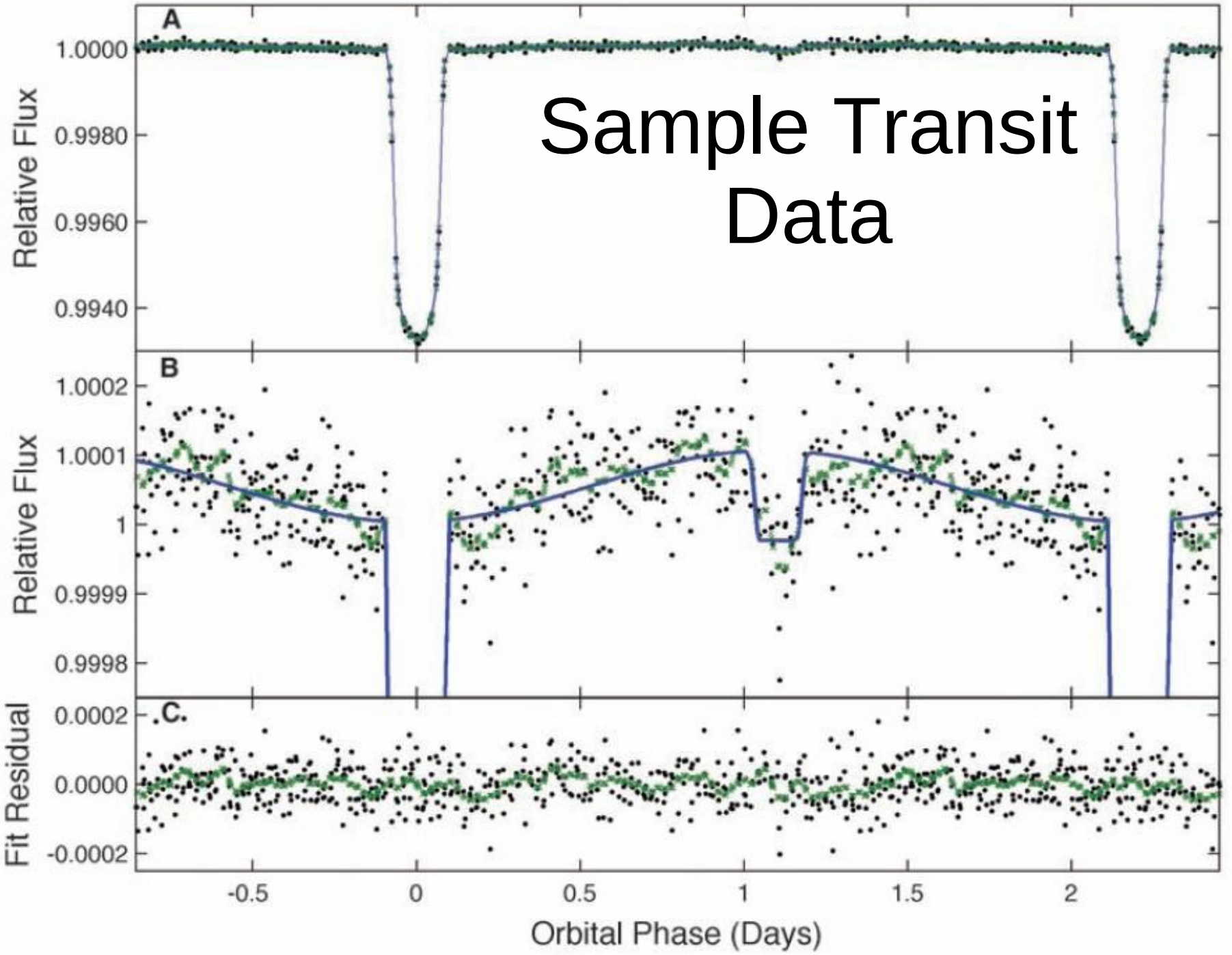
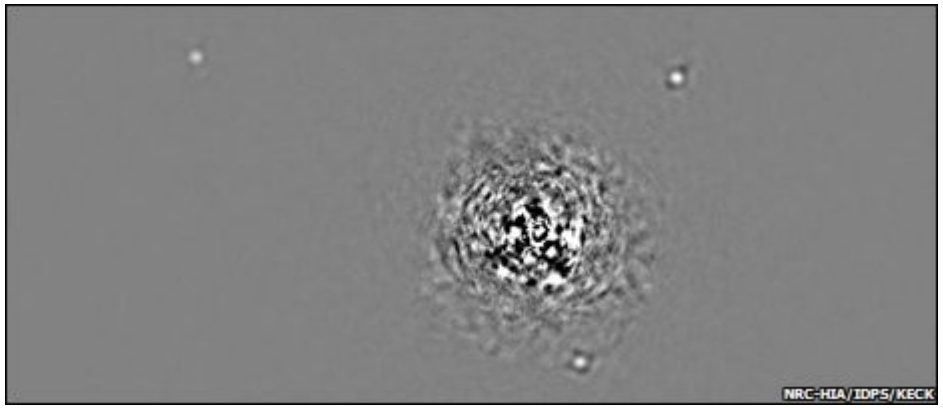
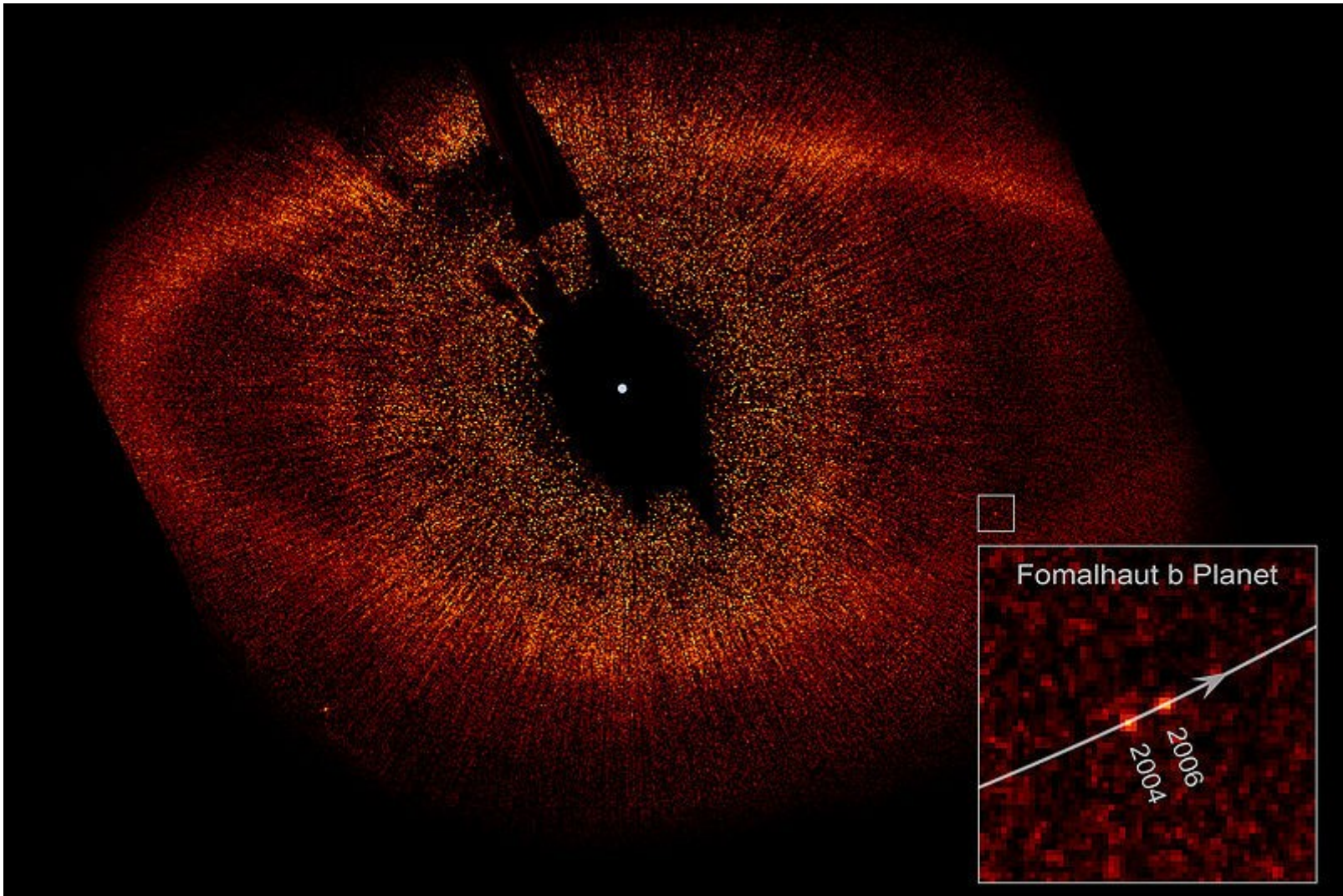


Fig. 1. Light curve for HAT-P-7b obtained by folding 10 days of data by the fitted orbital period. The black dots are the measurements. The green × marks are 0.1-day moving averages over the data. The blue line is a simple fit. (**A**) Light curve showing full depth of transit. (**B**) Expanded view to show phase curve and occultation. (**C**) Residuals from fit.

Direct Detection

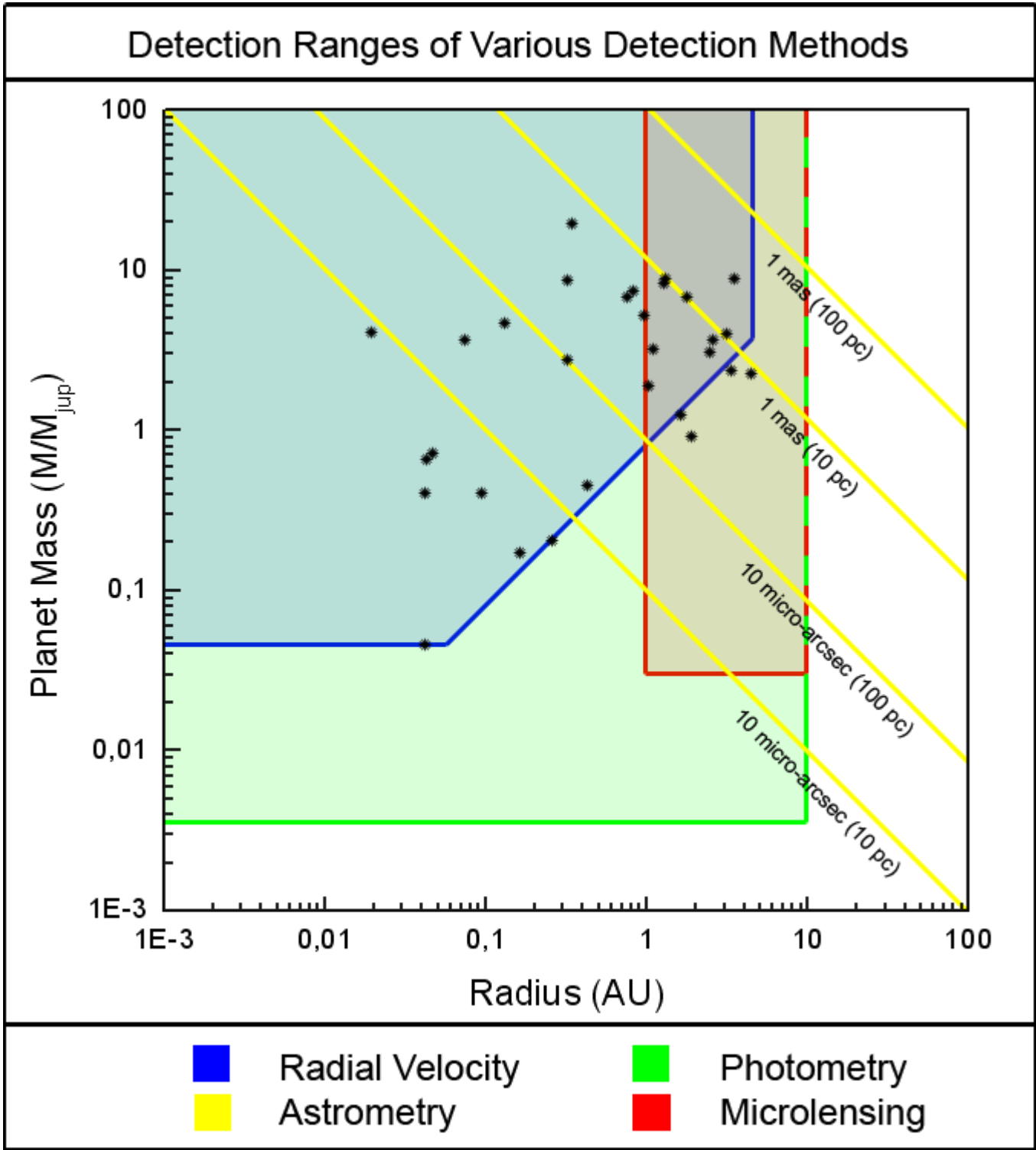




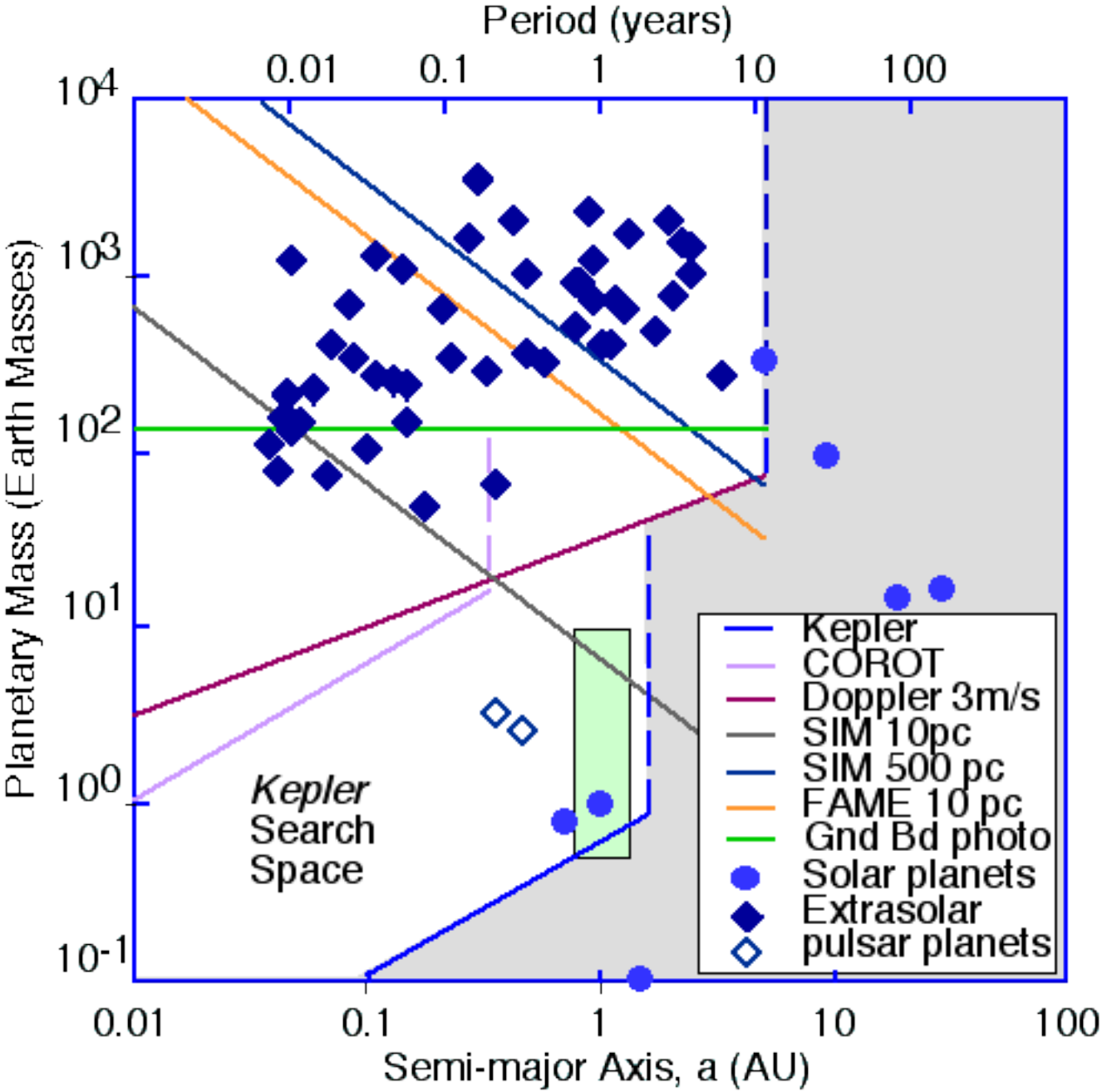
Other Methods

- There are a number of other methods that could be used to detect planets.
  - Microlensing
  - Disk signatures
  - New methods

Summary Figure

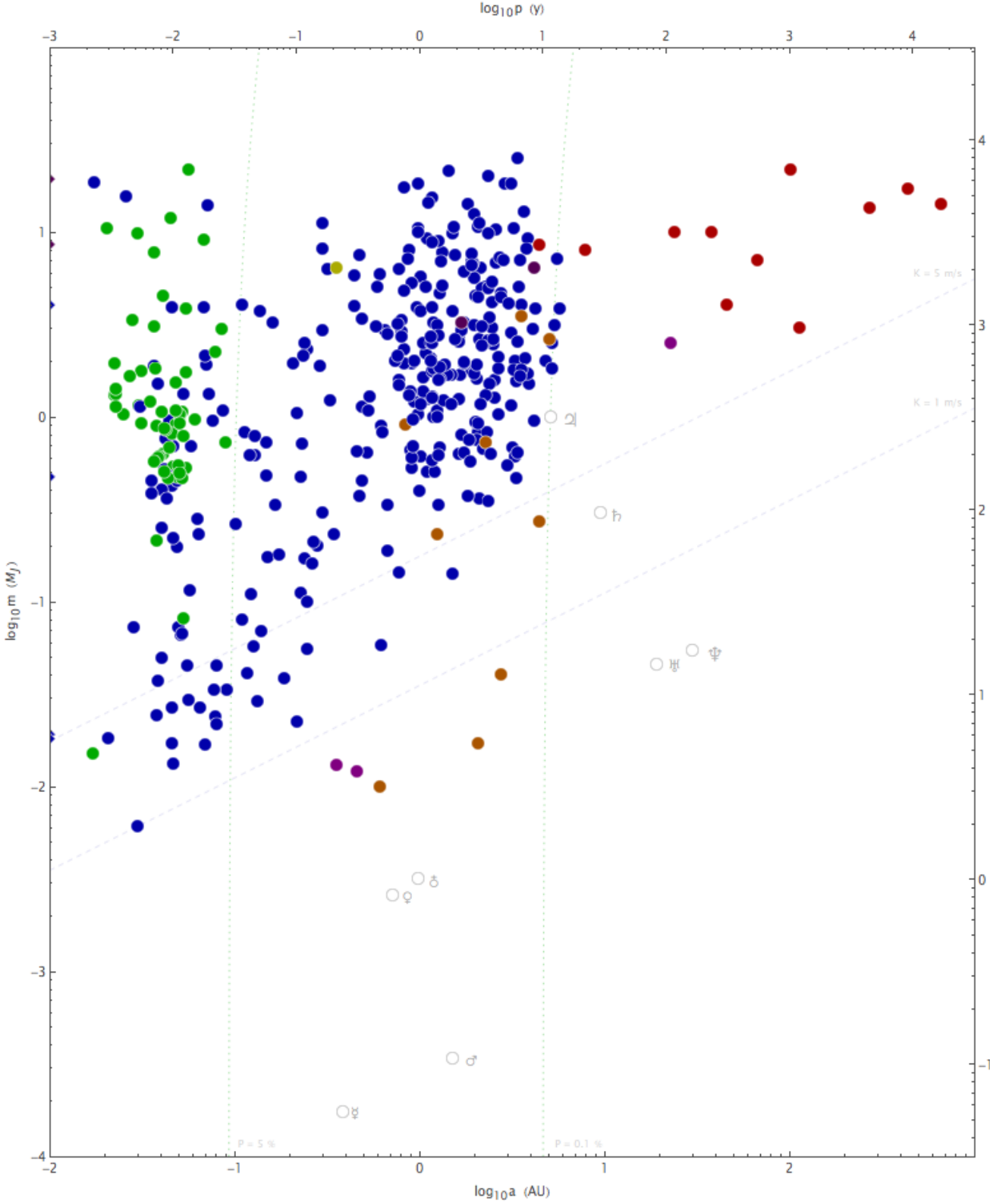


Kepler Limits



Known Exoplanets

- radial velocity = dark blue
- transit = dark green
- astrometry = dark yellow
- direct imaging = dark red
- microlensing = dark orange



Minute Essay

- What questions do you have about today's topic?