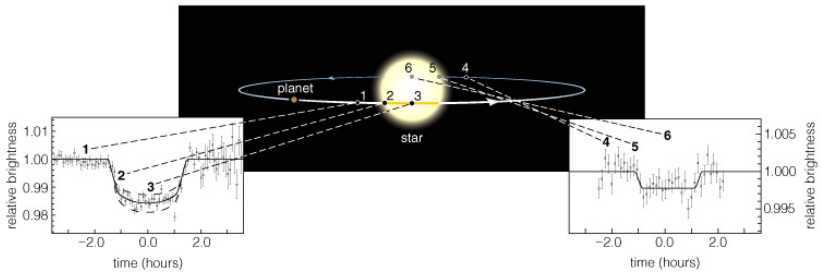
Quiz 5 Feedback

1. What properties of an exoplanet can you determine if the from transit measurements? from Doppler measurements?

Transit measurements give you *radius* or physical size of the planet, as well as the orbital period. Doppler measurements give you the orbital period and an indication of the planet's *mass*; if you do not know the orbital tilt, this is only a minimum possible mass.

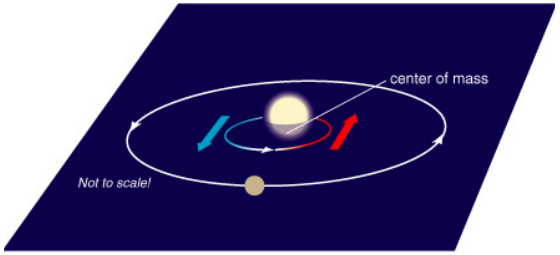
If you have both, then you know the approximate orbital tilt (nearly edge-on), therefore the actual planet mass. And the mass and radius of the planet together tell you the average density, hence some ideas of the possible composition (rocky, gaseous, etc.).

Transit Method



- A **transit** is when a planet crosses in front of a star
- The resulting (partial) eclipse reduces the star's apparent brightness and tells us planet's radius
- The orbital tilt is known (it must be nearly edge-on), so you can determine the actual planet mass

Planet Mass and Orbit Tilt



- We cannot measure the true mass for a planet without knowing the orbital tilt, because the Doppler shift tells us only the *radial* velocity (for an orbit in the plane of the sky, the shift is zero!)
- The Doppler method gives us only the ***lowest possible*** mass; it could be (and most likely is) larger.
- It may be possible to decipher the tilt by combining astrometric and spectroscopic observations

Follow-up to Kepler Detections

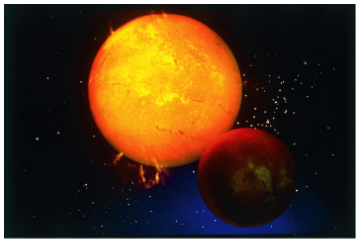
- Kepler finds apparent transits (drop-outs in light curves); these are designated "candidates" or "Kepler Objects of Interest" – e.g. KOI 22.
- Some turn out to be binary star systems.
- If the dips turn out to be due to an exoplanet, you get a measure of the ***radius*** ("size") of the planet
- To get a mass for the planet you need to go back to using the *Doppler method*. Then you know the orbit's inclination angle, so you have the actual ***mass***.
- With mass and radius, you can compute the planet's overall ***density***, which implies its composition.

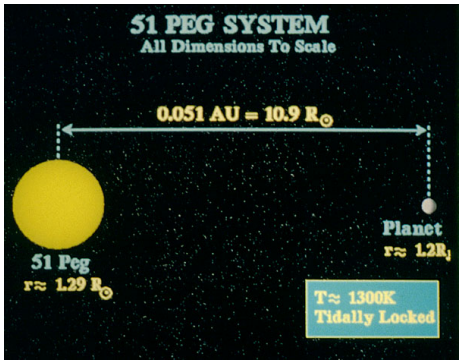
Quiz 5 Feedback

2. "Hot Jupiters"; why did the Kepler satellite find these first, and the more Earth-like planets later?

Hot Jupiters are massive (Jupiter-like) planets in close orbits around their parent stars – the first such planet discovered was 51 Peg b. Such small orbits have short periods, which is why Kepler found those planets first: in order to recognize that a planet is present, it is necessary to see the transit repeat. Only after it had been operating for a few years was it possible to detect planets in orbits with periods as long as one year (Earth-like orbits).

The Planet Orbiting 51 Peg





This planet has a mass similar to Jupiter's despite being so close to its star

New class of planets: **"Hot Jupiters"**

Appropriate (not always correct) Responses

- For the transit method: "A bigger radius [for the planet] would make it easier to detect." Yes, a planet with a larger radius will cover up more of the star.
- "Large mass and radius…" The mass does not directly affect the ease of detection. A planet made of low density material would have a smaller mass than one of the same radius made of denser material, but the dimming of the star's light *will be the same for both*.
- "Small orbital size and period." With a short period, astronomers monitoring the star will more quickly be able to recognize the presence of the planet(s).

Common Misunderstandings

- On question 1, some people were unclear on which method gives information about which properties. In particular, transits *do not* give an indication of mass, because they do not measure the gravitational tug, but only how much light is blocked (diameter). Just picture the planet in front of star!
- A number of students were confused about which method the *Kepler* satellite is using to search for exoplanets. *Kepler* uses the transit method (light curves) to notice planets. Some of you said it was the Doppler or position wobble method.