Group Card Activity, Oct. 11

It is beginning to look like there exist exoplanets with a wide range of physical and orbital properties. Yet for each search method we tend to find the planets with properties that are favorable for that method.

For the three most common methods of planet hunting – (a) positional shifts (astrometric), (b) Doppler shifts (spectroscopic), and (c) transits (light curves) – **what values of the planet's mass, radius, and orbital size or period are easiest to detect?** Assume they are all orbiting stars of about a solar mass.

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The great majority of the class ***did not answer the question*** that was asked – see bold face text on the previous slide). Instead of discussing what masses, radii, and orbital sizes or periods (the last two go together) make an exoplanet ***easy to detect***, most students just associated each of the mentioned properties with one or more of the detection methods, without specifying whether large, small, etc. values are favorable. These responses don't make sense. On a quiz or exam, failure to read the question carefully, resulting in such a non-answer will lead to loss of credit (or zero credit).

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).

Appropriate (not all correct) Responses

- For the positional shift method: "A greater mass and smaller orbit would be easier to detect." A more massive planet causes a larger wobble for the star, but it also helps to have a *larger* semi-major axis, because that also increases the positional shift for the star.
- "Astrometric method is best for hot Jupiters." Certainly not.! Hot Jupiters have tiny orbits. They are much more easily detected through the Doppler effect, because their high masses and close-in orbits both work to raise the orbital velocity. This is in fact why the hot Jupiters were *discovered* in the first place by the Doppler method!

Appropriate (not all correct) Responses

- For the Doppler method: "Larger orbital period would be easiest to detect." No, the opposite is true. Most planet searches have not been going on long enough to see a complete period for Jupiter (12 yrs), let alone Saturn (30 yrs). Also, the orbital velocity is actually ***slower*** for larger orbits (from Kepler's Third law).
- "Larger orbital sizes because the change in the distance becomes more ~~announced~~ pronounced." The Doppler shift ***does not depend on a change in distance***; it depends on the instantaneous velocity. A more massive planet exerts a stronger gravitational tug on its star, hence a higher orbital velocity, as shown in an animation shown in class on 10/11.

Confusions and Misunderstandings

- Many groups associated the transit method with the mass of the exoplanet. This is incorrect. In fact, the transit method is the only one of the three 'standard' methods for which the mass *doesn't* play a direct role. Transits tell you only geometric facts. Specifically, they tell you the ratio of the planet's radius to the radius of the star. You also measure the orbital period, but this mainly reflects the mass of the parent star, since the planet's mass is tiny compared to the star's.
- "Luminosity matters therefore mass and radius do." The meaning of this is unclear. Perhaps you are thinking about the previous card, about low-mass stars. Talking about the luminosity of the planet makes no sense for indirect methods.
- "Radius – light curve." This is what you observe, in the transit method. But that's not what the question asked.