Astrobiology Problem Set #1

Due Friday Oct 25

Several friendly aliens are living near the nearby star Alderamin (distance = 50 ly). Over their radio, they hear the rocking sounds of The Grateful Dead over radio waves emanating from the Sun. They immediately decide to build some telescopes and point them toward the Sun in order to search for planets.

1) They start looking for planets using transit measurements. Calculate the length and the depth of a transit which would be caused by each of the 9 planets passing in front of the Sun. (That is, individually calculate the length and depth by Mercury, by Venus, etc). Of the nine planets, which one has the longest duration? Which one has the deepest?

You can assume that the plane of the solar system is aligned with the direction to Sirius. You can also assume circular orbits.

2) The Alderaminians decide to move on to doppler radial velocity measurements. They build a telescope capable of resolving the radial velocity of the Sun to 5 meters/second. Of the planets in our solar system, which of the nine would be detectable from its radial velocity motions? Which would be the easiest to resolve?

3) After their studies of the solar system, they decide to build a telescope capable of directly imaging large-scale structure of the Solar System. How big a telescope would it take to resolve the system out to Pluto? To Jupiter? To Mercury?

Assume that they need about five pixels to image an orbit -- that is, to image the solar system out to Pluto, assume they can do it if their telescope can resolve five pixels spanning the distance between the Earth and Pluto. And, assume that their telescope is 'diffraction limited' in the optical -- that is, the angular size of a pixel is the angular resolution of the telescope, at a wavelength of 550 nm.

4) Let's say the Alderaminians were in no rush to contact us. They decide to wait 5 billion years, until the Sun's mass has gone down to half its current mass.

First, what does this do to the orbits of the planets? How does this change their orbital distances (that is, their semi-major axis)? Hint: You can assume that the angular momentum L = mrv of each planet around the Sun remains fixed over time, because changing the mass of the central star doesn't impart any torque on an orbiting body.

Second, now that the planets are in their new orbits, describe how this affects the detectability of the planets from Alderamin. What change is made to the detectability of planets by transits? What about by radial velocity measurements?