Astronomy 82 — Problem Set #3

Due by midnight on Sunday, April 18

1. You measure the radial velocity wobble of a star and find a velocity amplitude of ±5 meters per second and a period of 30 days. You also measure the spectrum of the star and determine that it is a main-sequence A1 star, which has a mass of 2 $M_\odot$.

   a) How massive is the planet causing the wobble of the star, and

   b) how far away from the star is it?

   The inclination of the planet's orbit is unknown, so express your answers in terms of the unknown inclination, *i*, of the planet's orbit with respect to your line of sight.

2. Now, you notice that the same planet undergoes transits across the face of the star, and thereby diminishes the light of the star by 1% at the bottom of the light-curve dip. You consult your favorite stellar reference manual (or the internet) to find that main-sequence A stars of this subtype (A1) have radii of 1.75 $R_\odot$.

   a) What is the average density of this planet?

   b) After noticing the transit, what can you say about the inclination of the planet's orbit? And what characteristics of the light curve could you use to refine the inclination even further?

3. A planet in a circular orbit around a fictitious nearby star exactly like the Sun has twice the diameter of the Earth and is 2 AU from the star.

a) What is the ratio of intensities of the star and the planet at visual wavelengths, assuming that the only light we see from the planet is scattered light from the star, and that the albedo of the planet is 0.3?

b) What is the ratio of intensities of the star and the planet at a wavelength of 12 μm, assuming that the planet emits only thermal radiation (i.e., negligible scattering at that wavelength), and has the same albedo as in part a). Assume that the planet is rotating fairly quickly on its axis (see problem set #2).

c) Same as b), but for a wavelength of 4 μm. Then comment on what wavelength might be best to use to search for planets using direct imaging. Besides comparing your answers to parts a), b) and c), what other consideration would need to be taken into account to answer this question fully (hint: think optics)?