

Course 12.425. Problem Set 5. Due Tuesday 20 Nov. 2007.

For all problems be sure to show your work including all steps taken.

1. Exoplanet Detection: Direct Imaging vs. Radial Velocity

In class we discussed the planet candidate 2M1207 discovered by direct imaging. This planet has an estimated mass of $4 M_J$, a semi-major axis of 46 AU, and a brown dwarf parent star with $M = 0.025 M_\odot$. Is it feasible to detect this planet by the radial velocity method? Use formulae developed in past lectures.

2. Planet Atmosphere Scale Height.

Some humans climb to the summit of Mt. Everest without requiring bottled oxygen. On a super Earth, how high could they climb without bottled oxygen, assuming the same surface atmospheric pressure as on Earth. Consider that Earth's atmospheric scale height is 7.4 km, and the super Earth has $a = 0.1$ AU, $M = 10M_\oplus$, $R = 1.5R_\oplus$, and orbits a sun-like star. Use the scale height definition from class lecture notes.

3. Atmospheric Escape

In class we discussed atmospheric escape as the primary sink for atmospheric loss.

a. Derive a formula for escape velocity.

b. Make a plot of star luminosity (in units of solar luminosity L_\odot) (y axis) vs. escape velocity (x axis) for all solar system planets and Earth's moon. On the same plot, plot all transiting exoplanets. You may find the transiting exoplanet data from the website <http://exoplanet.eu/catalog.php>, but only consider exoplanets with measured masses and radii. Because star luminosity data is not available, you may assume that

$$\frac{L}{L_\odot} = \left(\frac{M}{M_\odot} \right)^{3/5}. \quad (1)$$

If an exoplanet's host star's mass and/or radius is not available, make your best guess. Hint: use a log/log plot.

c. Based on the plot from 3b, discuss (in one to two paragraphs) which solar system planets are affected by atmospheric escape and which exoplanets may be affected by atmospheric escape.

d. Based on the plot from 3b, choose a planet mass, radius, and semi-major axis for a planet orbiting a sun-like star that would be dramatically affected by atmospheric escape.