

Extrasolar Planets:
Tuesday, October 2, 2007
12.425 Class Summary
Lecture 6

The focus of this class is to discuss solar system planet densities, review transit light curves and radial velocity curves, and then calculate exoplanet densities and surface gravities.

The first exercise in class was to calculate the densities of the planets in our solar system. Density, denoted as ρ , was calculated in terms of both Earth and Jupiter masses using the scaling formula: ρ_{planet} (in grams per cubic centimeter) = $\rho_J M_p [M_J] / R_p^3 [R_J^3]$. Densities in ratio to Jupiter's density (1.33 g/cm³) were: Mercury- 4.156; Venus-6.753; Earth- 5.6; Mars- 3.5; Jupiter- 1.0; Saturn- .75; Uranus- 1.25; Neptune- 1.64.

From this students gained an understanding of planet density and how it relates to planet composition—the rocky planets being the densest, the ice giants less dense than the rocky planets, but more dense than the gas giants. With that understanding, students could then compare the densities that they compute for exoplanets in Exercise 2.

Review of transit light curves and radial velocity curves was to help students remember how to calculate planet mass and radius so they could then calculate the exoplanet density. Exercise two has three examples and students work in pairs to calculate one planet density. Students were reminded to use the scaling formula to find the mass of the planet with the radial velocity curve. Using this formula (given in lecture 6 notes; pg. 25), students calculated the planet mass taking the radial velocity semi-amplitude, or K value, from the radial velocity light curve, which is the semi-amplitude of the radial velocity curve. To calculate the radius of the exoplanet, students used the transit light curve and the formula: $r_p = r_* \sqrt{\Delta F}$, where ΔF is drop

in luminosity as the planet transits the star. Students were given the planet period and mass and radius of the star.

Answers to the three examples are given in the lecture slides, and students will notice the odd densities of HAT-P-2b (11.9 g/cm^3) and TrES-4 ($.2 \text{ g/cm}^3$). The first is two times as dense as Earth and the second is five times less dense than Jupiter—representing oddities that astronomers are working to explain.

The discussion of density led to lecture on surface gravity and students completed Exercise 3 using the data and measurements from the previous exercise. The surface gravity formula is given on lecture slide 40. Note that t_T is the duration of the transit. Students found the surface gravity of GJ 436b at 20 m/s^2 ; TrES-4 at 7 m/s^2 ; and HAT-P-2b at 227 m/s^2 .

Lecture concludes with a look at how surface gravity relates to orbital period. Students' calculations fit on the observed inverse relation between gravity and orbital period supporting the trend that more massive planets with higher surface gravities are closer to their star. This trend is not reflected in our solar system and is another anomaly left for scientists to explore.