Extrasolar Planets:
Thursday, October 11, 2007
12.425 Class Summary
Lecture 7

The focus of this class is to discuss the basic composition and structure of planets, how they are compressed based the relation between pressure and gravity, how to calculate the pressure at planets' interiors, and how to estimate central pressure of planets.

The first exercise is to calculate the average density of the listed planets first when the pressure is equal to zero and then using a pressure-dependent density. Lecture slide 18 gives the zero-pressure density of certain basic materials that compose planets. The only density at P=0 that needs to be calculated is Earth by multiplying the known densities by the percentages given on slide 19. The two densities should then be added.

The second step to this problem is to calculate the average density using the planets' mass and radius data given on slide 20. Note: average $\rho = 3M / 4\pi R^3$. It is also important to note that mass and radius are given in kilograms, respectively, and density is in g per cubic centimeter. The calculated densities in grams per cubic centimeter were: Earth: P=0 5.46 and 5.5; 10 Earth mass silicate planet: 4.10 and 6.9; 10 Earth mass water ice planet: 1.46 and 3.1; and the 10 solar mass iron planet: 8.3 and 20.3. Comparing densities at P=0 against actual pressure demonstrates that compression occurs most on massive planets such as the hypothetical iron planet where the density was almost three times greater when pressured is considered.

The second exercise is to estimate the central pressures of the given planets using the data provided on slide 20. After reviewing planet interior equations and hydrostatic equilibrium, students will understand that central pressure, $P_C = 3GM^2 / 8\pi R^4$. Units should be in giga-pascals, which is 10^9 pascals (kg/m-s^2). Answers are given in the lecture notes. Students will see that again the most massive planets like the iron planet have the most extreme central pressures, and also that the central pressure for Earth is six orders of magnitude greater than standard atmospheric pressure.