Extrasolar Planets:
Tuesday, October 15, 2007
12.425 Class Summary
Lecture 8

The focus of this class is to discuss equations of state, phase diagrams, methods for measuring equations of state and the analytical forms of those equations.

The first exercise students will complete familiarizes them with phase diagrams and allows them to understand the phases of hydrogen, water, iron, and silicate present in planets based on pressure and correlated temperature. Students will take the data given on slides 15, 16, and 17, and plot the pressure and temperature on the diagrams given on slides 5, 7, 11, and 12.

When students plot pressure versus temperature for Neptune and Jupiter on the Hydrogen phase diagram, the result is shown on slide 8, they will note how hot the two planets are at their core. As the pressure increases, representing probing deeper into the core of the planets, the temperature rises so that at the core the planets reach a metallic hydrogen state suggesting the convection within in these planets is extremely high. Plotting temperature versus pressure on the water phase diagram shows that Neptune's curves passes into the supercritical fluid region of the graph, suggesting that water is present as a vapor and a liquid in equilibrium. The third grouping, which asks students to plot pressure versus temperature for iron illustrates how hot Earth is at its core. Plotting data for the hypothetical exo-planet at a constant temperature illustrates also how pressure changes and how the maximum pressure on the exo-planet is compared to Earth. Earth's maximum pressure is 367 giga-pascals, while the ten earth mass exo-planet is shown to have a maximum pressure of 1000 giga-pascals—a quantity that does not fit on this graphical representation of pressure versus temperature for iron. The final plot shows the silicate phase

diagram and this plot illustrates that when discussing the composition of a ten-earth mass exo-planet at high pressures, it could be made of persovskite and post-perovskite.

The second exercise asks students to review different graphs and decide whether they represent: 1. the ideal gas law; 2. a polytrope; or 3. Vinet's Equation of State all of which are given on slide 27. The diagrams and explanations complete the lecture slide set and also discuss the modified polytrope, which combines a Vinet EOS with a polytrope. The example is on slide 38. Students may note that the upper limit to the right represents the EOS and the lower left represents the polytrope. The beginning of the upward slope is hard to mathematically categorize, but the curve allows scientists to understand an overvall global perspective of the EOS.