Astronomy 201a: STELLAR and PLANETARY ASTROPHYSICS

FINAL EXAM

Start-time: Friday, January 12, 2007, at Noon.

The Exam must be turned in by: Tuesday, January 16, 2007, Noon.

You must turn in the Exam by the stated time – we'll have to reduce the grade for late submissions by the number of hours they are late. Joel and I will be grading the exams on Jan. 16th afternoon, after they are due and submit the final grades that same day. Please do not discuss the exam with anyone, or collaborate on any part of it. You can use the textbook, or any other references, as well as your lecture notes.

1. Thermal instability of degenerate gases. Explosive hydrogen burning at the bottom of a thin hydrogen-rich layer on the surface of a white dwarf will eventually lead to the expulsion of this layer. Such an outburst is known as Nova.
(a) For a white dwarf of mass $M = M_{\odot}$ and radius $R = 0.01R_{\odot}$, calculate the fraction, f, of the layer's mass that has to be transformed into helium in order to supply the energy necessary for expulsion, assuming the layer to be of solar composition;
(b) Derive the dependence of f on M for $M < M_{Chandra}$. Explain your derivations.

2. Consider the newly discovered transiting planet WASP-1b and the best parameters known for it and its star to date (astro-ph/0609688 and 0610589, and http://vo.obspm.fr/exoplanetes/encyclo/catalog-RV.php).
(a) Derive the formula for a planet's equilibrium temperature, T_{eq}, and estimate it for WASP-1b with the Bond albedo limit of 0.10 derived for the transiting planet HD 209458b by MOST. Discuss the uncertainties given the poorly known stellar parameters.
(b) Derive the formula for thermal atmospheric escape (e.g., equation 4.80 in de Pater & Lissauer). Use it to derive the rate of escape of atomic hydrogen from the upper atmosphere of WASP-1b. Assume that the scale height is constant in the upper atmosphere (exosphere) and that the atmopshere is isothermal ($T = T_{eq}$) due to the irradiation from the star. Discuss the assumptions. How does the loss of hydrogen affect the planet mass over its presumed age?

3. The solar corona is only $\sim 10^{-6}$ of the total brightness of the sun. The corona shines thanks to the scattering of solar light off free electrons. With this knowledge estimate the mass of the solar corona. How does its mass compare to the mass of, e.g. the Earth's atmosphere ?

4. A typical Cepheid variable star is a radially pulsating star with a bolometric magnitude amplitude of $\Delta m_{\rm bol} \sim 1mag$, and an effective temperature variation between $5500K$ and $7000K$. The observed radial velocity curve and light ($m_{\rm bol}$) curve are almost mirror images of each other; the stellar radius is at minimum during maximum brightness. Estimate the relative change of the radius $\Delta R/R$ of this Cepheid during its pulsation and find its (the radius change) contribution to the overall light curve amplitude.