PHYS633 Introduction to Stellar Astrophysics Spring 2008

Homework 5: Transitions in the hydrogen equation of state

Due in class on Wednesday, April 9th, 2008

For pure hydrogen, draw a $\log_{10}(T) - \log_{10}(\rho)$ diagram showing:

a) The transition from non-degenerate to non-relativistic degenerate electrons (assuming complete ionization).

b) The transition from non-relativistic to relativistic degenerate electrons (assuming complete ionization).

c) The transition from perfect gas pressure to radiation pressure (i.e. where $\beta = 0.5$). Again assume complete ionization.

d) The location of the ionization zone. For the ionization zone boundaries, use $f = 0.1$ and $f = 0.9$.

e) A line that indicates where 'pressure ionization' becomes important. In the semi-classical picture of orbital size, this occurs when the atomic size is about the mean separation between atoms. The atomic size for the ground state is the Bohr radius,

$$a_0 = 5.28\,10^{-11}\ \mathrm{m}.$$

The mean separation, a, can be taken to be given by

$$\frac{4\pi n_0 a^3}{3} = 1$$

where n_0 is the number density of H atoms.

Clearly label each line or curve. Take $\log_{10} T$ to range from 3 to 9. Truncate the thermal ionization curves at the pressure ionization boundary.