PHYS 5383
Spring 2012
TE Coan
Due: 24 Apr '12 6:00 pm

Homework 5

1. Calculate the mean mass density $\bar{\rho}$ of our Sun. Show your work and box your answer.

2. Calculate the electron degeneracy pressure $P_{\rm deg}$ for the case when the electrons are relativistic. This means that their energy is not $E = p^2/2m$ but $E = pc$.

3. Suppose you have a star of mass $M = 0.9M_\odot$ that is no longer producing energy through nuclear reactions but is held up by electron degeneracy pressure. What is its equilibrium radius R_{eq}? Assume you can use the non-relativistic expression for the degeneracy pressure and ignore subtle effects like any possible spinning.

4. Now suppose you have a star of mass $M = 5M_\odot$ that is no longer producing energy through nuclear reactions. Its mass is above the so-called Chandrasekhar limit so that the star is composed primarily of neutrons. (The electrons have disappeared through the reaction $e^- + p \rightarrow n + \nu$.) Gravitational attraction tends to crush it while degeneracy pressure opposes the gravitational compression.

a) What is the equilibrium radius $R_{\rm eq}$ of this object, called a "neutron star"?

b) What is the mean mass density $\bar{\rho}$ of this neutron star? Compare its mass density to the mass density of a lead coconut. You may want to express your answer as a ratio.

5. Calculate the Fermi energy E_F of a gas of fermions assumed to be massless, so that their energy-momentum relationship is $E = pc$. Express your answer in terms of the number density n of these fermions. Show your work.