**PHYS 5383**
Spring 2013
TE Coan
Due: 3 May '13 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 $R_{\rm eq}$ of this "white dwarf" star? Assume you can use the non-relativistic expression for the degeneracy pressure and ignore subtle effects like any possible spinning. The white dwarf is electrically neutral. Nobody got rid of the nuclei. A question for thought (you do not need to write down the answer): Why would such an object be called "white"? Think temperature.

**4.** Now suppose you have a star of mass $M = 1.8M_\odot$ 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 sensible 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.