ASTRONOMY 320: RELATIVISTIC ASTROPHYSICS

Winter Quarter 1999

Homework Set 3

Due Tuesday, 9 February 1999

1. Exercise 4.2 in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro & Teukolsky. Write down the ratio Ω_p/ω_D as a function of density ρ, and evaluate the ratio for $\rho = 10^5$ and 10^7 g cm^{-3}. [This problem shows that it is Ω_p, not w_D, that is relevant to the ion lattice in a white dwarf interior, and has you evaluate how important this is.]

2. Show explicitly that Eq. (4.4.5) in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro & Teukolsky can be written as Eq. (4.4.10) using the "usual" Debye approximation. [This problem makes you think carefully about how the various assumptions involved in the Debye approximation come in to the expression for c_V.]

3. Exercise 4.5 in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro & Teukolsky. [This problem shows why the longitudinal mode does not contribute to the heat capacity of the ion lattice in a white dwarf interior at low T.]

4. Show explicitly that equation (4.4.52) in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro & Teukolsky becomes equation (4.4.54) in the limit $T \to 0$, $y \to \infty$, and $\kappa \to 0$. [This problem makes you think about how the low-T expression for c_V comes about.]

5. Exercise 4.6 in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro & Teukolsky.

6. Exercise 4.7 in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro & Teukolsky.

7. Using the results of Chapters 3 and 4 in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro & Teukolsky, plot as solid lines in the Hertzsprung-Russell diagram ($\log T_e$ versus $\log L/L_\odot$) the cooling tracks of 0.2, 0.6, and 1.0 $M_\odot$ ^{12}C white dwarfs. Plot as dashed lines the white dwarf cooling ages $\tau_{\rm age} = 3 \times 10^8, 10^9$, and 3×10^9 years.

8. Using the results of Chapters 3 and 4 in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro & Teukolsky, plot as solid lines in the Hertzsprung-Russell diagram ($\log T_e$ versus $\log L/L_\odot$) the cooling tracks of 0.2, 0.6, and 1.0 $M_\odot$ ^{12}C white dwarfs. Plot as a dotted line $T_c = T_{\rm crys}$ and as a dashed line $T_c = \theta_D$.