AS4023 STARS

STELLAR STRUCTURE

Problem Sheet 2

1. Confirm that electrons inside the Sun are non-relativistic and classical.
2. Derive the equivalent equation of state for an ultra-relativistic electron gas:

$$P = K_{UR} n^{4/3}, \text{ where } K_{UR} = \frac{hc}{4}\left[\frac{3}{8\pi}\right]^{1/3}.$$

3. Give examples where each of the following transport processes dominates in stars: *photon conduction, electron conduction, neutrino conduction, convection.*
4. The opacity in the interiors of main-sequence stars is dominated at high temperatures by electron scattering $\kappa_{es} = 0.02(1+X)$ m^2 kg^{-1}, and at intermediate temperatures by bound-free absorption, $\kappa_{bf} = 4.34 \times 10^{24} Z(1+X)\rho T^{3.5}$ m^2 kg^{-1}.

   Illustrate how the position of the main sequence may be modified by (a) a change in hydrogen abundance X, and (b) a change in metallicity Z.

   Show how this accounts for the position of cool subdwarfs in the HR diagram and for the shape of the main sequence in HR diagrams of young open clusters.
5. Given that the three proton-burning chains involve the following nuclear species: PP1: H, ^{3}He and ^{4}He only; PP2: H, ^{3}He, ^{4}He, ^{7}Be and ^{7}Li; PP3: H, ^{3}He, ^{4}He, ^{7}Be, ^{8}B, ^{8}Be, attempt to write out the three chains *without* reference to notes. This is a good exercise in applying the various conservation laws of nuclear physics (charge, mass, spin).
6. Calculate the approximate maximum energy carried by neutrinos from each of the PP chains and also from the CNO cycle. The nuclear mass of ^{4}He is 3.973690 m_p; $m_p = 938.2731$ MeV c^{-2}; $m_e = 0.5109991$ MeV c^{-2}. [PP1: 0.26 MeV; PP2: 0.77 MeV; PP3: 7.1 MeV; CNO: 1.76 MeV]
7. Describe what role neutrinos play during main-sequence, red-giant and white-dwarf evolution, and during Type II supernova detonation.