Suppementary Exercises
for
An Introduction to Stellar Astrophysics
by Francis LeBlanc
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1.A Sirus A is a main-sequence star of spectral type A0 with an apparent visual magnitude of -1.47. Theoretical calculations show that the absolute visual magnitude for such a star is 1.42. Calculate its distance to Earth in light-years. (Answer: 8.61 ly)

1.B The atmosphere of certain white dwarfs are composed of almost pure helium. Calculate the ionisation fraction of all three helium ions at a depth where the electronic pressure is P_e = 175 dy/cm^2 and the temperature is T = 30000 K in such a star. The ionisation energies for helium are given in Appendix D and you may assume that the partitions functions for helium ions are the following: U_1 = 1, U_2 = 2 and U_3 = 1. (Answers: $f_1 = 9.36\times10^{-4}$ %, f_2 = 82.4 % and f_3 = 17.6 %)

2.A If we assumed that no thermonuclear energy was available in the Sun and that all of the energy emitted is due to gravitational energy (through its contraction), by what value (in km) would its radius contract over a period of a century assuming that its luminosity stays constant at $L_\odot$)? You may approximate the gravitational energy of the Sun by Eq. 2.49 (see page 46). (Answer: 7.4 km)

2.B Assume a spherical interstellar cloud of radius R_c and with a density profile given by the following expression

$$\rho(r) = \rho_0\left(1-\frac{r}{R_c}\right)^2$$

where ρ_0 is the central density. Calculate the mass of the cloud as a function of ρ_0 and R_c. (Answer : $\frac{2\pi}{15}\rho_0 R_c^3$)

4.A For an absorption atomic line found in a star's spectrum, do the photons found at its center come from deeper or shallower layers of the atmosphere than those found in the wings of the line? Why?

5.A With the data shown in Figure 5.14 representing the classical Cepheid star δ Cephei, approximate by what factor the luminosity in the photometric band related to the magnitude shown changes from its minimal value? (Answer: $L_{max} \approx 2.1\ L_{min}$)

6.A Estimate how many neutrinos per second are emitted by the Sun. You may assume that its luminosity is due entirely to PPI reactions. What is the flux of solar neutrinos on Earth (in units of neutrinos/s/cm^2)? (Answers: 1.8×10^{38} neutrinos/s and 6.4×10^{10} neutrinos/s/cm^2)

6.B Calculate the energy liberated by the nuclear reaction $^7\mathrm{Li} + {}^1\mathrm{H} \rightarrow 2\,^4\mathrm{He}$ found in the PPII chain. (Answer: 16.84 MeV)

6.C Assume a star born a population III but now at the helium burning stage. It therefore contains only H, He and C. If its composition is $X = 0.70$, $Y = 0.27$ and $Z = 0.03$, what is the relative number of hydrogen atoms to carbon ones? (Answer: 280)

6.D Nuclear processes leading to a supernova explosion include the following nuclear reaction: $^{56}\mathrm{Fe} + \gamma \rightarrow 13\,^4\mathrm{He} + 4\mathrm{n}$. Calculate the energy taken away from the thermal bath during this photodisintegration reaction. (Answer: 124.4 MeV)