ASTR 401 HW 1
Due Thursday Sept 10, 2020, 5pm

(1) (Phillips 1.1) Consider a sphere of mass M and radius R. Calculate the gravitational potential energy of the sphere assuming (a) a density which is independent of the distance from the center, and (b) a density which increases towards the center according to

$$\rho(r) = \rho_C(1 - r/R)$$

In both cases, (a) and (b), write down the average internal pressure needed for hydrostatic equilibrium, and determine how the pressure within the sphere depends on the distance from the center.

(2) (Phillips 1.3) As the Sun evolved toward the main sequence, it contracted under gravity while remaining close to hydrostatic equilibrium, and its internal temperature changed from about 30,000 K to about 6×10^6 K. Find the total energy radiated during this contraction. Assume that the luminosity during this contraction is comparable to the present luminosity of the Sun and estimate the time taken to reach the main sequence. (5 pts)

(3) (Phillips 1.4) Given that the luminosity of the Sun is 4×10^{26} W and that the absolute bolometric magnitude of the Sun is $M_B = 4.72$, estimate the distance at which the Sun could just be seen by the naked eye. (The naked eye can detected a star of apparent magnitude 6). Estimate the number of photons incidence on the eye per second in this situation. (5 pts)

(4) (i) Using the solar compositions from Lecture 3, derive the mean atomic mass of stellar material and the number of free electrons per nucleon for the Sun (5 pts). (ii) Repeat this calculation assuming the cases of a) all Hydrogen, b) all Helium, and c) all heavy elements. (10 pts)

(5) The Gaia survey has recently released a data set for the parallaxes over over 1 billion stars in the Milky Way Galaxy. Using data from the Gala public data website (*https* : *//gea.esac.esa.int/archive/*)
make a color-magnitude diagram for stars that are less than 10 pc the Sun. See if you can identify the main sequence, giant, and white dwarf regions in the figure. The following script should help you get started downloading the Gaia data,

SELECT gaia.$*$
WHERE gaia.parallax $> XX$

instead of gaia.$*$

gaia.phot_g_mean_mag
gaia.phot_bp_mean_mag
gaia.phot_rp_mean_mag gaia.parallax

Repeat the same exercise for stars within 20 and 50 pc of the Sun. Explain the difference between the CMD for 20 pc and 50 pc distance cuts.

Write out the steps that you took to make the figure (you don't have to turn in any code that you write) (15 pts).