ASTR702 - HW8
November 14, 2024, Due November 22, 2024
2 pt each part

1) a) During a glitch, the period of the Crab pulsar decreased by $|\Delta P| \simeq 10^{-8} P$. Assuming this was due to contraction of the neutron star, estimate the change in the star's radius assuming an initial radius of 10 km.
b) Suppose that the Sun were to collapse down to the size of a neutron star (10 km radius). Assuming that no mass is lost in the collapse, find the rotation period of the neutron star. (assume here that it's the entire Sun's mass that forms the neutron star).
c) Find the magnetic field strength of this neutron star.
d) The Sun will of course become a white dwarf and not a neutron star. Use a radius ratio to very roughly estimate the white dwarf rotation speed.

2) (a) At what speed do relativistic effects become important at a level of 10%. In other words, for what value of $v$ does the lorentz factor $\gamma$ become equal to 1.1?
(b) Estimate the density of the white dwarf for which the speed of a degenerate electron is equal to the value found in part (a).

3) Determine the minimum rotation period for a 1.4 solar mass neutron star (the fastest it can spin without flying apart). Assume that the star remains spherical with a radius of 10 km.

4) Find the expression for the temperature in the outer layer of a white dwarf using the equation of hydrostatic equilibrium and the ideal gas law.

5) Because your friends and family are going to ask at Thanksgiving...
a) 1 tsp of white dwarf weights as much as how many elephants (fully explain all assumptions)?
b) Neutron stars have radii of about 10 km. 1 tsp of neutron star weighs as much as how many elephants (fully explain all assumptions)?
c) If a white dwarf were made entirely out of elephants, how many elephants would you need to crush together to make a white dwarf?

6) (Grad students only) Consider a pulsar that has a period $P_0$ and period derivative $\dot{P}_0$ at $t = 0$. Assume that the product $P\dot{P}$ remains constant for the pulsar (c.f. Eq. 16.29 in CO).
(a) Integrate to obtain an expression for the pulsar's period $P$ at time $t$.
(b) Imagine that you have constructed a clock that would keep time by counting the radio pulsars received from this pulsar. Suppose you also have a perfect clock ($\dot{P} = 0$) that is initially synchronized with the pulsar clock when they both read zero. Show that when the perfect clock displays the characteristic lifetime $P_0/\dot{P}_0$, the time displayed by the pulsar clock is $(\sqrt{3} - 1)\, P_0/\dot{P}_0$.