

In general, I expect you to work problems out from first principles—the goal is to develop the skills of applying your basic physics to astrophysical situations, not to apply random formulas. I expect you to be clear and justify any assumptions you make in working out these problems. I expect you to show all steps. If you look up any quantities, you must provide references.

1. Do a more exact calculation of the rate of rest mass loss of the sun due to fusion reactions. Assume that the reactions are the p-p cycle of reactions and that they supply the entire luminosity of the sun.
2. The radius of nuclei can be approximated by $r(A)=1.4A^{1/3}$ where A is the atomic number.
 - a) Using this relationship and the mass of a uranium-238 nucleus, arrive at a value for the density of the Uranium nucleus in kg/m^3 .
 - b) Assuming that neutron star material is the same density as you found in a), what is the expected radius of a 1 solar mass neutron star?
3. Find a reference for the value of the magnetic field of the sun—make sure it is at a sensible location, like the pole or equator (report the reference). We argued in class that the magnetic field of conducting fluid (e.g. solar plasma) is “frozen in” such that the number of field lines is fixed. Another way of saying this is that the magnetic flux is constant: $\int \mathbf{B} \cdot d\mathbf{A} = \text{constant}$.
 - a) Assuming a 10 solar mass star has a size roughly twice that of our sun ($v \sim r^3$) and same size magnetic field, if it shrinks to the size of the neutron star you found above in 2b), find an estimate for the magnetic field after contraction.
4. For a 1 solar mass neutron star such as in 2b)
 - a) What is the speed of a hydrogen atom that falls in from $r=\infty$ when it hits the surface?
 - b) If the corresponding kinetic energy were thermal, what would be the characteristic temperature?
 - c) What would be the wavelength of maximum black body radiation emitted at this temperature? And what type of radiation would you classify it as (e.g. visible, infrared, etc.)?
5. For the neutron star in 2b)
 - a) What is the orbital speed just at its surface?
 - b) What is “ g ” at its surface?
 - c) If it rotates 30 times per second (like the Crab nebula pulsar), what is the tangential speed of the surface?