Homework # 5

Due before Tuesday, December 15th

README: Make sure you write down all steps to solve the problems, so that I can give partial credit if needed. If I do not see the procedure you followed to solve the problem, you will get a zero on that problem. Also, be careful with units: they are extremely important! Only use the constants and values provided to solve the problems. Finally, make sure you write neatly so that I can understand it: if I don't understand what you wrote, you will get a zero. Scan the solution (into a single PDF, preferably) and send it back to me before the deadline. When a comparison between quantities is asked for, you need to calculate the ratio between the two quantities. When asked to make a figure/ plot/diagram, make sure you produce this figure electronically, either with python coding (preferably) or with Excel (or similar).

CONSTANTS and OTHER VALUES (only use the provided constants/values to solve the problems):

1 pc = 3.0857×10^{16} m	1 radian = 206264 arcsec	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
1 year = 3.1557×10^{7} s	$c = 3 \times 10^{5}$ km s^{-1}	$R_{Earth} = 6.3781 \times 10^{6}$ m
$M_{Sun} = 1.989 \times 10^{30}$ kg	$R_{Sun} = 6.95508 \times 10^{8}$ m	$L_{Sun} = 3.839 \times 10^{26}$ W
$M_{Moon}=7.35 \times 10^{22}$ kg	$R_{Moon}=1.7381 \times 10^{6}$ m	

Rotation period of the Sun: P_{Sun} = 26 days
Magnetic field strength of the Sun: $B_{Sun} = 2 \times 10^{-4}$ T
Boltzmann constant: $k = 1.38065 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}
Planck constant: $h = 6.62607004 \times 10^{-34}$ m^2 kg s^{-1}
Stefan-Boltzmann constant sigma = 5.6704×10^{-8} W m^{-2} K^{-4}
1 eV = 1.0622×10^{-19} J

1) The angular size of the Crab supernova remnant is 4 arcmin x 2 arcmin and its distance from Earth is approximately 2000 pc. Estimate the linear dimensions of the nebula in pc. Using the measured expansion rate of the Crab (1450 km/s) and ignoring any accelerations since the time of the supernova explosion, estimate the age of the nebula in years.

2) Taking the distance to the Crab supernova remnant to be 2000 pc, and assuming that the absolute bolometric magnitude at maximum brightness was characteristic of a Type II (i.e., core collapse) supernova (M_{bol} = -17), estimate its peak apparent magnitude. Compare this to the maximum brightness of the planet Venus (m = -4), which is sometimes visible in the daytime. Could the Crab supernova have been visible during the daytime?

3) The neutrino flux from SN 1987A was estimated to be 1.3×10^{14} m^{-2} at the location of Earth. if the average energy per neutrino was ~4.2 MeV, estimate the amount of energy released via

neutrinos during the supernova explosion assuming isotropic emission of neutrinos. SN1987A went off in the Large Magellanic Cloud, which is a dwarf galaxy at a distance of 51.4 kpc from Earth.

4) If our Moon were as dense as a white dwarf (~3×10^6 g cm^{-3}), what would be its radius in units of Earth's radius? Compare this with the actual radius of the Moon.

5) If our Moon were as dense as a neutron star(~6.65×10^{17} kg m^{-3}), what would be its radius in units of m?

6) 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 in seconds. Find the magnetic field strength of the neutron star.