Astronomy 1F03: Assignment 3

Due Date: Tuesday 15th Nov, 2016; hand in to **ABB241 by 2pm** (10% per day late penalty)

Write your answers on a separate sheet showing your working and explaining any formulae you use.

1. A star 15 parsecs from the Sun is observed to have a proper motion of 0.23 arcseconds per year. (a) What is its true transverse velocity in km/sec? (b) If its spectral lines are observed to be Doppler shifted by $\Delta\lambda/\lambda = 0.0005$, what is its three dimensional space velocity in km/sec?

2. Consider the evolution of a small star as it evolves from the main sequence. Let the star have a luminosity on the main sequence of L_{MS}.

    a. As the star becomes a red giant, its surface temperature decreases by a factor of 2 and its radius increases by a factor of 50. Calculate the ratio of the red giant's luminosity, L_{RG}, to the main sequence luminosity, that is, calculate L_{RG}/L_{MS}.

    b. Eventually, the star loses its outer layers as a planetary nebula exposing a new white dwarf. Compared with the original main-sequence star, the white dwarf has a surface temperature 10 times as high and a radius 100 times smaller. Calculate the ratio of the white dwarf's luminosity, L_{WD}, to the main sequence luminosity, that is, calculate L_{WD}/L_{MS}.

3. A certain telescope could just detect the Sun at a distance of 10,000 pc. What would be the Sun's apparent magnitude at this distance? What is the maximum distance at which this same telescope could detect a nova with peak luminosity of $10^5 L_\odot$? Repeat the calculation for a supernova with a peak luminosity of $10^{10} L_\odot$.

4. Consider a 2m tall person falling feet first into a black hole. Calculate the tidal acceleration on the person, that is, the difference in the acceleration due to the black hole's gravity on the person's feet and head (assume Newtonian gravity). Calculate this difference when the person's feet just enter the event horizon. Calculate answers for three black hole masses: $1M_\odot$, $10^6 M_\odot$ and $10^9 M_\odot$. Express your answers in terms of the gravitational acceleration at the surface of the Earth, $g=9.8$ m s^{-2}. (Note that a person can withstand about 10g.)

5. An unstable elementary particle at rest in the lab frame decays in 2μs. If a beam of these particles is accelerated to 99.99% the speed of light, how long do the particles take to decay in the laboratory frame?