Physics 310/610 – Cosmology

Homework Set D

1. The table at right shows those spectral lines of hydrogen that are in the range 4000-7000 Å (left column) and the observed spectral lines of a distant star (right column).

Reference	Observed
6562.7 Å	5265.8 Å
4861.3 Å	4701.6 Å
4340.5 Å	4443.0 Å
4101.7 Å	4300.4 Å
	4212.7 Å
	4154.5 Å

   (a) One possibility is that the first observed spectral line is a blue-shifted version of the first reference line. If this were the case, then other lines on the right would have the same ratio λ_0/λ. Convince yourself that that this is <u>not</u> the case, in other words, the other spectral lines don't match up.
   (b) Another possibility is that the first observed spectral line is a red-shifted version of the *second* reference line. If this is the case, then other lines on the right would have the same ratio λ_0/λ. Convince yourself that that this <u>is</u> the case, in other words, the other spectral lines <u>do</u> match up.
   (c) Find the red-shift z and the velocity v_r of the star

2. In class I gave an approximate formula for the luminosity of a star, namely $L = L_\odot \left(M/M_\odot\right)^{3.5}$, where M is the mass of the star (confusingly, M is also used for the absolute magnitude). You may want to present your answers to this question in the form of a table.
   a) Work out the luminosity, in terms of solar luminosities, for stars of mass 0.1, 0.3, 1, 3, 10, and 30 solar masses
   b) Assuming they are placed at a distance of 10 pc from the Earth. What would be their apparent brightness F, in W/m^2?
   c) Find their apparent magnitude m at this distance. What is the absolute magnitude M of these stars?
   d) Suppose these same stars were brought to a distance of 1 kpc instead. How would their apparent and absolute magnitudes change?

Graduate Problem – Do if you are in PHY 610

3. Suppose an object is moving at an angle θ compared to straight towards you at a speed v that is less than but comparable to the speed of light c.
   (Although this problem involves relativistic velocities, there is no relativity in this problem)
   (a) Assume the object starts at a point P and moves to a point Q for a time t. How much closer is it to you at time t? How much delay Δt is there between when you receive light from P and light from Q?
   (b) What is the transverse distance d_T that the object moves during this time? Find the apparent transverse velocity $v_{aT} = d_T/\Delta t$ as a function of v and θ.
   (c) Find the maximum value $v_{\max}$ of v_{aT} as a function of θ for fixed v. Note that it is larger than v; i.e., $v_{\max} > v$. What is the smallest value of v such that we can have $v_{\max} \geq c$?