Physics 3710 – Problem Set #10 *Relativistic gravity, III*

Problems 1-3 refer to: The maximum measured z value for a galaxy is 11.1. As on page 1, GR7, $z = \frac{\lambda_d - \lambda_e}{\lambda_e}$.

1. Suppose z is due to relative motion. Use the Doppler formula $\lambda_d = \left(\frac{1+\beta}{1-\beta}\right)^{1/2} \lambda_e$ to find the speed, β, with which this galaxy is receding from Earth.

2. Given that the universe scale factor is now 1, find a for this galaxy. (Equation (2), GR7, p4.)

3. What would the CMB temperature have been for this galaxy when it emitted the light we detect now? (GR8, p2)

4. Assume the universe contained only matter and vacuum-energy but with $\Omega_m = 0.27$ and $\Omega_V = 0.73$. Calculate the "age" of the universe in years by integrating $\int_0^a \frac{da'}{a'\sqrt{\frac{\Omega_m}{a'^3} + \Omega_V}} = tH_0$. Use the best-measured value of H_0 in the table on Gr9, p6.

(Note: according to Mathematica

$$\int \frac{dx}{\sqrt{(1-A)/x + Ax^2}} = \frac{2}{3\sqrt{A}} \ln\left[2\frac{\sqrt{Ax^3 + (1-A)} + \sqrt{Ax^3}}{\sqrt{1-A}}\right].)$$