Astro 425 Cosmology: Problem Set 5

Due December 7th 2016

1. [10 pts] Using the Friedman equation find values of $\Omega_{m,}, \Omega_{r,}, \Omega_{\Lambda}$ that will give rise to a
   (a) Loitering universe (use a universe with a positive matter density)
   (b) A big crunch universe

   Plot your results showing the scale factor as a function of time.

2. [10 pts] If a cluster of galaxies has a set of gravitational arcs (e.g. Einstein rings) we can use these arcs to calculate the mass internal to the inscribed circle. If we assume an isothermal sphere show that the velocity dispersion of the cluster is related to the angle of the arc in the image by

   $$\sigma_v \approx 10^3 \, kms^{-1} \left(\frac{\theta}{28"} \frac{D_S}{D_{LS}} \right)^{1/2}$$

   An isothermal sphere has a density profile $\rho(r) = \frac{\sigma_v^2}{2\pi G r^2}$

   Hint: think about the mass within the Einstein radius