Exercise 3

fredag 23. september 2016 13.26

1) Matter

$$E_{non-rel} = p^2 \propto a^{-2}$$

$$\langle E_{non-rel} \rangle = k_B T_{gas}$$

$$T_{gas} \propto a^{-2} = (1+z)^2$$

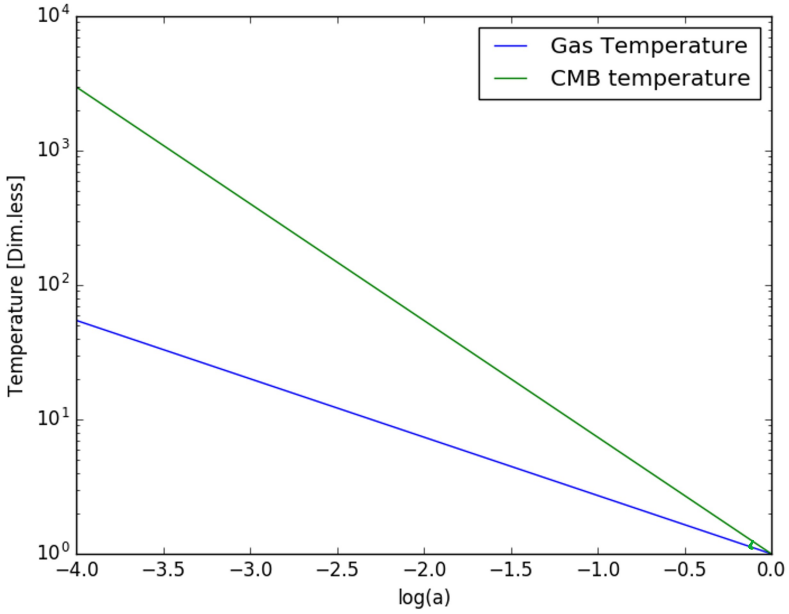
Radiation

$$E_\gamma \propto a^{-1} = (1+z)$$

$$\lambda = b/T \propto T^{-1}$$

$$\lambda \propto T^{-1}$$

$$T_\gamma^{bb} \propto a^{-1}$$



2) $\lambda_J = \frac{2\pi c_s}{\sqrt{4\pi G \rho_0}} \propto c_s$

$\bar{\rho}_m = \rho_0 a^{-3} \propto a^{-3}$

$c_s = \sqrt{\frac{k_B T}{\mu m_p}} \propto T^{1/2}$

$M_J = \frac{4\pi}{3}\left[\frac{\lambda_J}{2}\right]^3 \bar{\rho} \propto \lambda_J^3 \bar{\rho}$

$$M_J = \frac{4\pi}{3}\left[\frac{\lambda_J}{2}\right]^3 \rho \propto \lambda_J^3$$

$$\propto c_s^3 a^{-3}$$

$$\propto T^{3/2} a^{-3} \qquad (T_{gas} \propto a^{-2})$$

$$\propto (a^{-2})^{3/2} a^{-3}$$

$$\propto a^{-6} = (1+z)^6$$

$$\lambda_J \propto c_s \propto T_{gas}^{1/2} \propto a^{1} = (1+z)$$