Problem Set 8

Due **in class**, Thursday, 8 March 2018

Reading: See the on-line syllabus for lecture-by-lecture readings.

Collaboration policy: See the on-line collaboration policy.

Background (0pts)

In problem set 5, you showed the following, using the graph (Figure 1 below) for our CDM universe of the variance of mass fluctuations, filtered with a spherical top hat of comoving radius R (related to M by $M = 4\pi R^3 \langle \rho_0 \rangle /3$), as a function of the filter radius:

a) At $z = 11$, 2σ fluctuations which have just collapsed and virialized have approximately, $R = 0.1$ Mpc, masses of $1.5 \times 10^8 M_\odot$, virial radii of ~ 1.5 kpc, circular velocities of ~ 20km s^{-1}, and virial temperatures of $\sim 16,000$K.

b) At $z = 3$, 2σ fluctuations which have just collapsed and virialized have approximately, $R = 2.7$ Mpc, masses of $3 \times 10^{12} M_\odot$, virial radii of $\sim 10^2$ kpc, circular velocities of ~ 330km s^{-1}, and virial temperatures of $\sim 4 \times 10^6$K.

1. **Feedback in dwarf galaxies vs in giant galaxies** (12pts: 7+5)

   For the gas in the two halos ($1.5 \times 10^8 M_\odot$ and $3 \times 10^{12} M_\odot$) specified above, answer the following separately for each halo:

   a) Using the (hydrogen and helium curves only for primordial gas!) cooling curve in Fig 1a below, estimate the ratio of cooling time to collapse time for the gas in each of the two halos (assuming that the initial temperature is the virial temperature). Do you expect collapse and fragmentation or not? Discuss. How would your answer differ for the massive halo if its gas had been polluted to solar abundance?

   b) With a standard initial mass function, every 100 solar masses of gas turned into stars creates one supernova, with kinetic energy $\sim 10^{51}$erg. What fraction of the gas in each of the two halos needs to be converted to stars to produce enough kinetic energy to eject all the rest of the baryons in that halo?

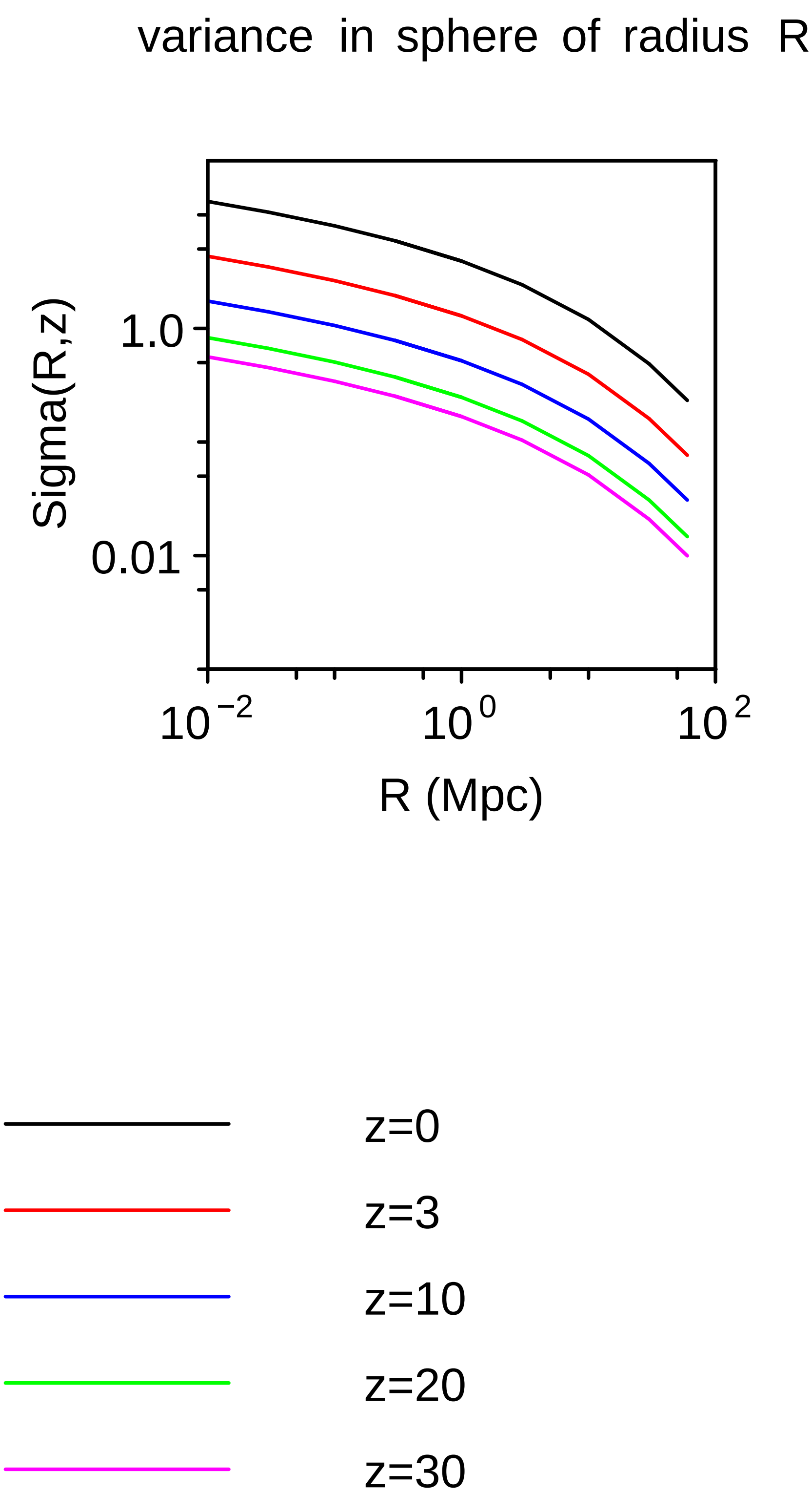

Figure 1: Top hat-filtered variance $\sigma_R = \sqrt{(\delta M/M)^2} = \int_0^\infty \Delta^2(k)W^2(kR)d\ln k$ in the mass enclosed within comoving radius R, for redshifts (top to bottom) 0,3,10,20,30. The Fourier Transform $W(kR)$ of the top-hat window function is defined in section 4.4.4 of MvdBW (eqs 4.271-4.273).

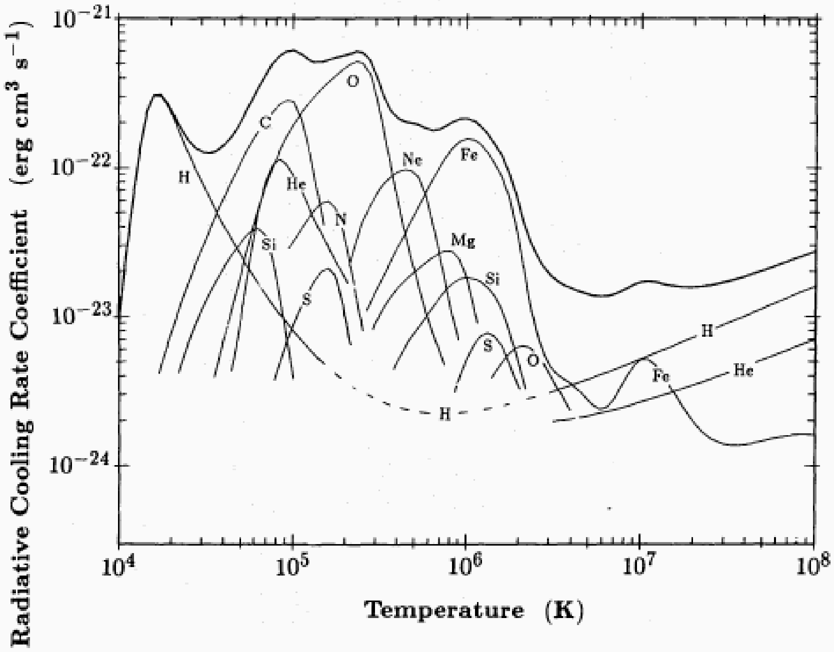

Fig. 2. Contribution of the different elements to the total radiative cooling coefficient for solar abundance of the elements