AST353 (Spring 2016) **ASTROPHYSICS Problem Set 2** Due in class: Thursday, February 18, 2016 (worth 10/100)

1. Spherical collapse

Consider a spherical region (an "overdensity") that is a bit denser than the background universe in which it is embedded. Assume that the background universe is described by the model that you have calculated in PS1, part 1.

Further assume that the overdense region is 1% denser than the background universe at a redshift of $z_i = 1,000$ (that is, the initial overdensity is $\delta_i = 10^{-2}$).

Calculate the redshift of collapse (or "virialization"), $z_{\rm vir}$, when all the dark matter (DM) particles are rushing towards the center of the region!

[NOTE: In effect, virialization is a bit like a mini Big Crunch. But the DM particles reach the center at slightly different times, so that in reality the outcome of the collapse is not a singularity (everything at radius zero at the same time), but a jumbled state where the kinetic energy of the DM particles is of the same order as their gravitational potential energy.]

HINT: You can solve this puzzle with what you have worked out in PS1, part 2.

2. WIMPs

Assume that the dark matter is made up of WIMPs with rest-energy of 100 GeV.

Estimate the velocity (in km s⁻¹) with which such WIMPs would move around in the halo of our Milky Way!