

## ASTR 680 Practice questions for lecture 15: Clusters, context, and cosmology

1. Suppose that a cluster has  $M = 10^{15} M_{\odot}$  within a radius of 2 Mpc. Calculate the average speed of the galaxies at that radius, and the typical temperature of the gas.

2. Consider a purely Newtonian system of noninteracting particles that starts as a uniform-density system in a perfect sphere of radius  $R$  and mass  $M$  (we assume there is a hard cutoff at  $R$ , i.e., no particles are outside  $R$  and the sphere has uniform density inside  $R$ ). Initially, no particle is moving, so the collection of particles collapses. Using energy conservation and the virial theorem (look this up if you don't know what it is), what would you expect to be the final characteristic radius of the system after it has virialized?