

Homework 10

Due April 15 at 10:45am via Canvas

Please show all work, writing solutions/explanations clearly, or no credit will be given. You are encouraged to work together, but everyone must turn in independent solutions: do not copy from others or from any other sources.

1. A volume containing a photon-baryon fluid is adiabatically expanded or compressed. The energy density of the fluid is $\varepsilon = \varepsilon_\gamma + \varepsilon_{\text{bary}}$, and the pressure is $P = P_\gamma = \varepsilon_\gamma/3$. What is $dP/d\varepsilon$ for the photon-baryon fluid? What is the sound speed c_s ? In Ryden Eq. 11.26, the effect of baryons on the Jeans length $\lambda_J(\text{before})$ was ignored; what is the more accurate estimate of $\lambda_J(\text{before})$ including baryons?
2. Suppose that the stars in a disk galaxy have a constant orbital speed v out to the edge of its spherical dark halo, at a distance R_{halo} from the galaxy's center. If a bound structure, such as a galaxy, forms by gravitational collapse of an initially small density perturbation, the minimum time for collapse is $t_{\text{min}} \approx t_{\text{dyn}} \approx 1/\sqrt{G\bar{\rho}}$. Show that $t_{\text{min}} \approx R_{\text{halo}}/v$ for a disk galaxy. What is t_{min} for our own galaxy? What is the maximum possible redshift at which you would expect to see galaxies comparable in v and R_{halo} to our own galaxy? Assume the Benchmark Model cosmology.
3. Within the Coma cluster (Ryden Section 7.3), galaxies have a root mean square velocity of $\langle v^2 \rangle^{1/2} \approx 1520$ km/s relative to the center of mass of the cluster. Its half-mass radius is $r_h \approx 1.5$ Mpc. Using arguments similar to those of problem 2 above, compute the minimum time t_{min} required for the Coma cluster to form by gravitational collapse.
4. **Presentation Prep:** Start making slides for your talk. In the process of designing a talk, it can become clear what you don't understand or know enough about, and if you wait until the last minute to compose the presentation, it's too late to dig into those issues. Feel free to come talk to me about anything you're confused by or need clarification on. Nothing needs to be submitted with the HW.