Homework 11

Due **April 22 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. For the Schechter luminosity function of galaxies, find the total luminosity density Ψ as a function of L^*, Φ^*, and α. What is the numerical value of the luminosity density Ψ_V in the V band, given $L_V^* = 2 \times 10^{10}\ L_{\odot,V}$, $\Phi^* = 0.005\ \mathrm{Mpc}^{-3}$, and $\alpha = -1$?

2. On a mass scale $M = 10^{17}\ \mathrm{M}_\odot$, the root mean square mass fluctuation is $\delta M/M = 0.12$ today (inferred from Ryden Figure 11.5). Do you expect to see any gravitationally collapsed structures with that mass in the directly visible universe today? Explain why or why not.

3. Consider the Big Rip scenario from HW 4, Problem #2 (`http://www.astro.utah.edu/~wik/courses/astr4080spring2021/hw/hw04.pdf`). Since the energy density has the dependence $\varepsilon \propto a^{-3(1+w)}$, the energy density ε_p (with $w_p < -1$) of phantom energy increases as the universe expands; when ε_p/c^2 becomes larger than the mass density of a bound object, the object will be ripped apart. Suppose that the universe contains both matter and phantom energy with $w_p = -1.1$.

   (a) If the density parameters of the two components are $\Omega_{m,0} = 0.3$ and $\Omega_{p,0} = 0.7$, at what scale factor a_{gal} will the descendent galaxy of the merger between the Milky Way and M31 be ripped apart?

   (b) At what scale factor a_* will a Sun-like star be ripped apart?

   (c) Using the result from the HW 4 problem, how many years before the Big Rip will that Sun-like star be ripped apart? [Hint: the Big Rip is defined as the time t_{rip} when $a \to \infty$.]