Outline

- Go over homework (8.3)
- Friedmann equations with cosmological constant
- Observable effects of cosmological constant/dark energy

Friedmann Equations

- First Friedmann equation: $$\left(\frac{\dot{R}}{R}\right)^2 = \frac{8\pi}{3} G\rho - \frac{k c^2}{R^2} + \frac{\Lambda}{3}$$

- Acceleration equation: $$\frac{\ddot{R}}{R} = -\frac{4\pi G}{3c^2}\left(\rho c^2 + 3P\right) + \frac{\Lambda}{3}$$

- Previously derived energy conservation equation from first two. Do that for the case with dark energy.

$$\dot{\rho} c^2 = -3\frac{\dot{R}}{R}\left(\rho c^2 + P\right)$$

Equation of State of the Universe

- Matter dominated: $\rho c^2 >> P$
  - Use energy conservation to show $\rho \sim R^{-3}$

- Radiation dominated: $P = (1/3)u = (1/3)\rho c^2$
  - Use energy conservation to show $\rho \sim R^{-4}$

- What is equation of state for Λ?
  - Use Friedmann equations substituting in ε_Λ and P_Λ.
  - Find $P_\Lambda = -\varepsilon_\Lambda$

Homework

- For next class, problem 8.5.