Ph 444 Problem Set 7

Due: Friday, November 14, 2014

1. The surface brightness Σ of an astronomical object is defined as its observed flux divided by its observed angular area; thus, $\Sigma \propto f/(\delta\theta)^2$. For a class of objects that are both standard candles and standard yardsticks, what is Σ as a function of redshift? Would observing the surface brightness of this class of objects be a useful way of determining the value of the deceleration parameter q_0? Why or why not?

2. This problem explores the number of type Ia supernova that would need to be observed at $z = 0.5$ to determine the dark energy equation of state parameter w to 1% accuracy. At this redshift, it is a reasonable approximation to adopt Ryden equation (7.45)

$$d_L \simeq \frac{c}{H_0} z \left[1 + \frac{1 - q_0}{2} z \right].$$

This leads to Ryden equation (7.52) for relation between the distance modulus of a supernova, $m - M$, and redshift. Assume that we know $\Omega_{m,0} = 0.3$ and $\Omega_{q,0} = 0.7$ precisely. Using how q_0 depends on $\Omega_{m,0}$, $\Omega_{q,0}$, and the w for the dark energy, determine how $m - M$ depends on w and z. If w is constant, then its value is determined by measuring distance moduli for one set of supernovae at small z (where the q_0 dependence is negligible) and another set at, say, $z = 0.5$. Explain why we need supernovae at both small and large z. The distance modulus to an individual type Ia supernova can be measured with an accuracy of ± 0.15 mag. How many supernovae must be measured, equally divided between small z and $z = 0.5$, to determine w for the dark energy to ± 0.01? Assume that there are no systematic errors, so that the uncertainty in the average distance modulus of a group of supernovae is determined only by the number of supernovae contributing to the average.

3. Ryden problem 8.1

4. Ryden problem 8.3