Two numbers and the CMB

(1) In the lecture we saw that the angular distance could be found by

$$d_A = \frac{S_k(r)}{1+z}.$$

This distance measurement is not one of the more frequently used measures even though galaxies and clusters of galaxies are both large enough to use as standard yardsticks at large distances. At your table discuss what the problem(s) is/are with this measurement.

(2) Suppose you observe a Cepheid variable star with a period of 26 days whose flux is 180 times less than that shown in the table in the lecture. Find the relative distance to the galaxy hosting that star.

(3) In the lecture we've discussed Type 1A supernova and Cepheid variable stars as possible standard candles. At your table, come up with a plan to build a *distance ladder* which can be used to find distances at cosmological scales.

(4) In the lecture we've listed 3 mathematical expressions

$$I_\nu = \frac{2h\nu^3}{c^2}\left[e^{h\nu/T} - 1\right]^{-1} \tag{1}$$

$$\langle T\rangle = \frac{1}{4\pi}\int T(\theta,\phi)\,\sin\theta\,d\theta\,d\phi \tag{2}$$

$$\frac{\delta T}{T}(\theta,\phi) \equiv \frac{T(\theta,\phi) - \langle T\rangle}{\langle T\rangle} \tag{3}$$

(a) For each equation, describe each term and what the left hand side of the equation physically is.

(b) Speculate on how the CMB came to existence, that is, speculate on what its physical origins are.

(c) Speculate on what you think it might mean that the temperature of the CMB is uniform across the whole sky to within one part in 10^5.

(5) In the lecture, you've been presented with three facts,

$$\sigma_e = 6.65\times10^{-29}\,\mathrm{m}^2;\ \lambda = \frac{1}{n_e\sigma_e};\ n_e = \frac{0.25\,\mathrm{m}^{-3}}{a^3}$$

(a) Given that photons travel with a speed c, find an expression for the rate at which photons scatter. Call this term Γ. (*Hint:* Think dimensionally).

(b) Use n_e and λ to find how often photons scatter when $a = 10^{-5}$.

(c) Write the Friedmann equation for this radiation dominated era. Given that $\Omega_{r,o} = 9.0 \times 10^{-5}$, find the Hubble parameter (in terms of a).

(d) Let $a = 10^{-5}$ and find the Hubble parameter. Compare this value to Γ obtained in part (b). Interpret your results.

Homework 03–Due Friday, Feb. 21

1. Problem 6.3
2. Problem 6.8
3. Problem 8.2
4. Problem 8.4