MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Physics Department

Physics 8.286: The Early Universe May 1, 2004
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ERRATA

Lecture Notes 7:

Correction Date: 4/2/04

The text between Eqs. (7.11) and (7.12) has been corrected, and Eq. (7.13) has been revised with the intent of making it clearer. The new text is as follows:

$$\rho_r/\rho_m \propto 1/R(t) \ . \tag{7.11}$$

If we assume for now that we live in an $\Omega_m = 0.33$ universe, then today $\rho_r/\rho_m \approx 8.0 \times 10^{-5}/0.33 \approx 2.4 \times 10^{-4}$. The constant of proportionality in Eq. (7.11) is then determined, giving

$$\frac{\rho_r(t)}{\rho_m(t)} = \frac{R(t_0)}{R(t)} \times 2.4 \times 10^{-4} \ . \tag{7.12}$$

. . . Thus, setting $\rho_r(t_{eq})/\rho_m(t_{eq}) = 1$ gives

$$\frac{R(t_{eq})}{R(t_0)} = \left(\frac{t_{eq}}{t_0}\right)^{2/3} = 2.4 \times 10^{-4} \ . \tag{7.13}$$

The version of Lecture Notes 7 now posted on the web has been corrected. All the changes are on page 3, the boundaries of which have not changed. So, if you have already printed Lecture Notes 7, you could just reprint page 3.

Problem Set 5:

Correction Date: 5/1/04

The first sentence of Problem 5 should read:

> Calculate numerically the result from Problem 1 for the case of a flat universe in which the critical density is comprised of nonrelativistic matter and vacuum energy (cosmological constant).

The original version erroneously said "from the previous problem".

The version of Problem Set 5 currently posted on the website has been corrected, and is marked as "Corrected Version: May 1, 2004".

Review Problems for Quiz 3:

Correction Date: 5/1/04

In the "Useful Information" section at the front of the review problems, the pressure of black-body radiation should be written

$$p = \frac{1}{3}u \qquad \rho = u/c^2 \qquad \text{(pressure, mass density)}$$

The original erroneous version included a minus sign in the pressure equation.

At the end of the solution to Problem 7, it should read:

> Rearranging the equation for $(\dot{x}/x)^2$ above,
>
> $$H_0\,\mathrm{d}t = \frac{\mathrm{d}x}{x\sqrt{\frac{\Omega_{m,0}}{x^3} + \frac{\Omega_{r,0}}{x^4} + \Omega_{v,0} + \frac{\Omega_{\mathrm{ms},0}}{x^{3/2}} + \frac{\Omega_{k,0}}{x^2}}}\ .$$
>
> The age of the universe is found by integrating over the full range of x, which starts from 0 when the universe is born, and is equal to 1 today. So
>
> $$\boxed{t_0 = \frac{1}{H_0}\int_0^1 \frac{\mathrm{d}x}{x\sqrt{\frac{\Omega_{m,0}}{x^3} + \frac{\Omega_{r,0}}{x^4} + \Omega_{v,0} + \frac{\Omega_{\mathrm{ms},0}}{x^{3/2}} + \frac{\Omega_{k,0}}{x^2}}}\ .}$$

The error was the omission of the H_0 factors. Immediately after the diagram in the solution to Problem 8, it should read

> In this picture $\Delta\theta$ is the angular size that would be measured. Using the $\mathrm{d}\theta^2$ part of the metric,
>
> $$\mathrm{d}s^2 = R^2(t)\sinh^2\psi\,\mathrm{d}\theta^2\ ,$$

The original erroneous version had a factor $\sinh^2\theta$ where it should be $\sinh^2\psi$.

The version of Review Problems for Quiz 3 currently posted on the website has been corrected, and is marked as "Corrected Version: May 1, 2004".