Lecture 10:
The Cosmic Microwave Background Part 2: Fluctuations in the CMB

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April 8, 2018

$$d_{\rm hor}(t_{\rm cmb}) = a(t_{\rm cmb})c\int_0^{t_{\rm cmb}} \frac{dt}{a(t)} = 2.24ct_{\rm cmb} = 0.251 \text{ Mpc} \tag{1}$$

$$\theta_{\rm hor} = \frac{d_{\rm hor}(t_{\rm cmb})}{d_A} = \frac{0.251 \text{ Mpc}}{12.8 \text{ Mpc}} = 0.020 \text{ rad} = 1.1^\circ \tag{2}$$

$$C(l) = \left\langle \frac{\delta T_1}{T}\frac{\delta T_2}{T} \right\rangle_l \tag{3}$$

$$d_{\rm hor} = a(t_{\rm ls})c\int_0^{t_{\rm ls}} \frac{dt}{a(t)} = 2.24t_{\rm ls} = 0.251 \text{ Mpc} \tag{4}$$

$$d_{\rm hor} = a(t_{\rm ls})c\int_0^{t_{\rm ls}} \frac{dt}{a(t)} = 2.24t_{\rm ls} = 0.251 \text{ Mpc} \tag{5}$$

$$d_{\rm s} = \ a(t_{\rm ls})\int_0^{t_{\rm ls}} \frac{c_{\rm s}(t)dt}{a(t)} = \ a(t_{\rm ls})\frac{c}{\sqrt{3}}\int_0^{t_{\rm ls}} \frac{dt}{a(t)} = \frac{d_{\rm hor}}{\sqrt{3}} = 0.145 \text{ Mpc} \tag{6}$$