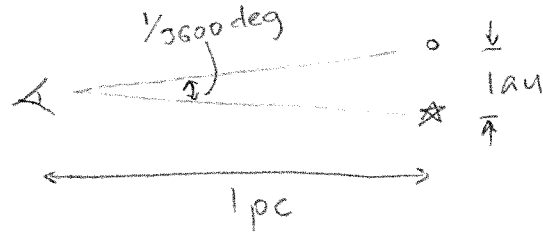


# A Units

A-1

astronomical unit (au) - mean Earth-Sun distance  
 $= 1.5 \times 10^{11} \text{ m}$

parsec (pc) - distance at which 1au subtends  
a second of arc ( $1''$ )



$$\therefore \frac{1.5 \times 10^{11} \text{ m}}{\tan\left(\frac{1}{3600} \text{ deg}\right)} = 3 \times 10^{16} \text{ m}$$

$$\begin{aligned} \text{a light year is } & 60 \times 60 \times 24 \times 365 \times 3 \times 10^8 \\ & = 9.5 \times 10^{15} \text{ m} \end{aligned}$$

$$\text{so } 1 \text{ pc} = 3.26 \text{ light years}$$

megaparsec (Mpc) -  $10^6 \text{ pc}$ , roughly the separation  
between neighbouring galaxies

## B Benchmark model

$$H_0 = 68 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

$$q_0 = -0.53$$

### ingredients

$$\left. \begin{array}{l} \text{photons } \Omega_{\gamma,0} = 5.35 \times 10^{-5} \\ \text{neutrinos } \Omega_{\nu,0} = 3.65 \times 10^{-5} \end{array} \right\} \text{radiation } 9 \times 10^{-5}$$

$$\left. \begin{array}{l} \text{baryonic matter } \Omega_{\text{bary},0} = 0.048 \\ \text{(nonbaryonic) dark matter } \Omega_{\text{dm},0} = 0.262 \end{array} \right\} \text{matter } 0.31$$

$$\text{cosmological constant } \Omega_{\Lambda,0} = 0.69 \quad \Lambda \quad 0.69$$

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### epochs

radiation-matter equality

$$a_{\text{rm}} = 2.9 \times 10^{-4}$$

$$t_{\text{rm}} = 0.05 \text{ Myr}$$

matter -  $\Lambda$  equality

$$a_{\text{m}\Lambda} = 0.77$$

$$t_{\text{m}\Lambda} = 10.2 \text{ Gyr}$$

now

$$a_0 = 1$$

$$t_0 = 13.7 \text{ Gyr}$$

### critical density

$$\epsilon_{c,0} = 8 \times 10^{-10} \text{ J m}^{-3} = 2 \times 10^{58} \text{ J Mpc}^{-3}$$

$$\rho_{c,0} = 9 \times 10^{-27} \text{ kg m}^{-3} = 10^{11} M_{\odot} \text{ Mpc}^{-3}$$