Ch. 1

Cosmology is the study of the universe, or cosmos, as a whole.

Cosmology deals with
- → distances that are very large
- → objects that are very big
- → timescales that are very long

SI units are very small

Units used by astronomers / cosmologists

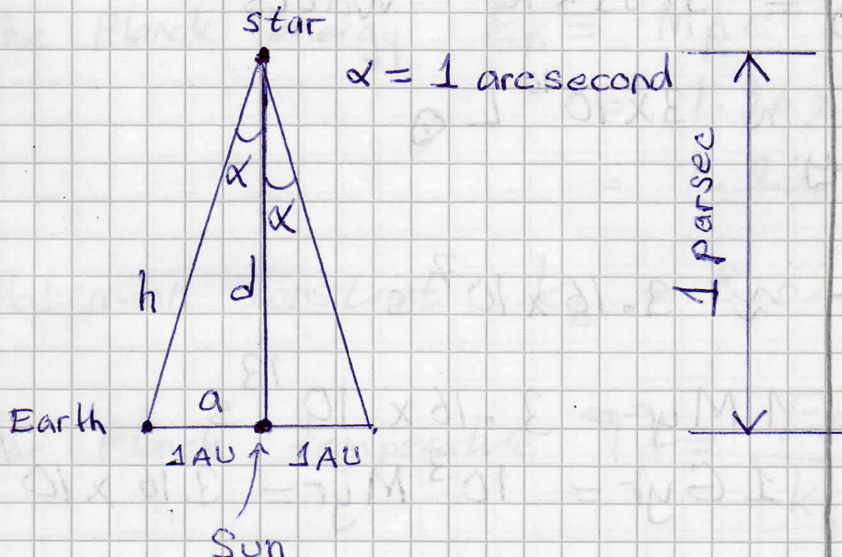
LENGTH:

Astronomical Unit AU = the mean distance between the Earth and Sun

$$1\,AU = 1.50 \times 10^{11}\,m$$

AU is small compared to distances between stars

Interstellar distances are measured in parsecs (pc)



$1° = 60$ arcmin $= 3600$ arcsec.

$= \frac{\pi}{180}$ rad

$1\,\text{arcsec} = \frac{\pi}{180 \times 3600}$ rad

$= \frac{1}{206265}$ rad

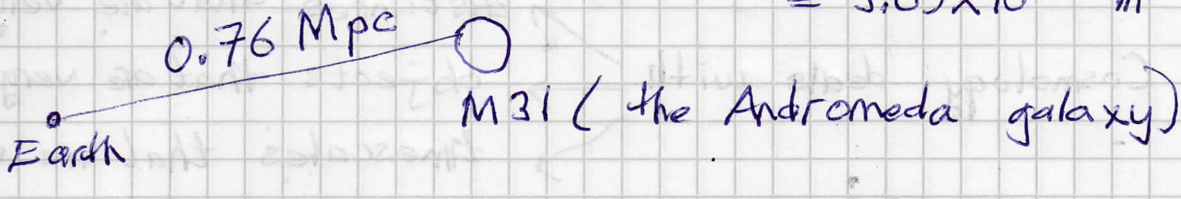
$$\tan\alpha = \frac{a}{d}$$

$$d = \frac{a}{\tan\alpha} \approx \frac{a}{\alpha} = \frac{1\,AU}{1\,\text{arcsec}} = \frac{1.5 \times 10^{11}\,m}{\frac{1}{206265}\,rad} = 3.09 \times 10^{16}\,m$$

$$1\,pc = 3.09 \times 10^{16}\,m = 206265\,AU$$

To measure intergalactic distances we use the Megaparsec (Mpc)

$$1\,Mpc = 10^6\,pc = 3.09 \times 10^{16+6}\,m = 3.09 \times 10^{22}\,m$$



MASS :

The standard unit of mass used by astronomers is the solar mass ($M_\odot$)

Sun's mass $\quad 1\,M_\odot = 1.99 \times 10^{30}\,kg$

$$M_{our\ galaxy} \sim 10^{12}\,M_\odot$$

$$\text{luminosity} = \frac{\text{energy radiated in the form of light}}{\text{time}}$$

$$1\,L_\odot = 3.83 \times 10^{26}\ \text{Watts}$$

$$L_{our\ galaxy} \sim 3 \times 10^{10}\,L_\odot$$

TIME :

$$1\,yr \approx 3.16 \times 10^{7}\,s$$

Megayear $\quad 1\,Myr = 3.16 \times 10^{13}\,s$

Gigayear $\quad 1\,Gyr = 10^3\,Myr = 3.16 \times 10^{16}\,s$

Age of the Earth $= 4.57\,Gyr$

ENERGY : $\quad 1\,eV = 1.60 \times 10^{-19}\,J$

Electron rest energy $\quad m_e c^2 = 0.511\,MeV$

Proton rest energy $m_p c^2 = 938.27$ MeV
$= 1836.1\ m_e c^2$

The Planck System of Units:

Newtonian gravitational constant $G = 6.67 \times 10^{-11}\ m^3 kg^{-1} s^{-2}$

speed of light $c = 2.9979 \times 10^8$ m/s
$= 3.00 \times 10^8$ m/s

reduced Planck constant, $\hbar = \frac{h}{2\pi} = 1.05 \times 10^{-34}$ Js
$= 6.58 \times 10^{-16}$ eV·s

the Planck length $l_p \equiv \left(\frac{G\hbar}{c^3}\right)^{1/2} = 1.62 \times 10^{-35}$ m

the Planck mass $M_p \equiv \left(\frac{\hbar c}{G}\right)^{1/2} = 2.18 \times 10^{-8}$ kg

the Planck time $t_p \equiv \left(\frac{G\hbar}{c^5}\right)^{1/2} = 5.39 \times 10^{-44}$ s

the Planck energy $E_p \equiv M_p c^2 = \left(\frac{\hbar c^5}{G}\right)^{1/2}$
$= 1.96 \times 10^9$ J
$= 1.22 \times 10^{28}$ eV

Bolzmann constant $k_B = 8.62 \times 10^{-5}\ eV K^{-1}$

the Planck temperature $T_p \equiv \frac{E_p}{k_B} = 1.42 \times 10^{32}$ K

$1\ ly = c \cdot lyr = 3 \times 10^8\ m/s \times 3.16 \times 10^7\ s = 9.48 \times 10^{15}$ m

$\frac{1\ pc}{1\ ly} = 3.09 \times 10^{16}\ m / 9.48 \times 10^{15}\ m = 3.26$

$1\ pc = 3.26\ ly = 3.09 \times 10^{16}$ m