5) $d = 2.3\ m$ $f/2.1$ $13.5\ \mu m$ pixel size

$\chi = 1$ (airmass) Q.E. $= 0.90$ $eff_t = 0.70$ $S/N = 100$ $t = ?$

$\mu = m + 2.5 \log \theta$

$V = 22$ V filter moon: $\mu_V = 20 \frac{mag}{\square''}$ seeing $= 1.1''$ from wiki: $\Delta\lambda_V = 88 \times 10^{-9} m$

$n_{read} = 4.5 \frac{e^-}{px}$ dark $= 0$

new moon $\mu_V = 22 \frac{mag}{\square''}$ how limited?

$V\ \lambda_{eff} = 0.56\ \mu m$

$$\frac{S}{N} = \frac{R_S t}{\sqrt{R_S t + n_{px}(R_B t + R_D t + N_R^2)}}$$

$$\left(\frac{S}{N}\right)^2 = \frac{R_S^2 t^2}{t(R_S + n_{px} R_B + n_{px} R_D) + n_{px} N_R^2}$$

$$t(R_S + n_{px} R_B + n_{px} R_D) = \frac{R_S^2 t^2}{(S/N)} - n_{px} N_R^2$$

$$0 = \left[\frac{R_S^2}{(S/N)}\right] t^2 - \left[R_S + n_{px} R_B + n_{px} R_D\right] t - n_{px} N_R^2$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$t = \frac{[R_S + n_{px} R_B + n_{px} R_D] \pm \sqrt{[R_S + n_{px} R_B + n_{px} R_D]^2 + 4 \cdot \left[\frac{R_S^2}{S/N}\right] n_{px} N_R^2}}{2\left[\frac{R_S^2}{(S/N)}\right]}$$

$R_D = 0$

$R = \eta_{total} \cdot \Delta\lambda \cdot A \cdot f_\lambda$

$f_{\nu_{[V]}} = 3540\ Jy \cdot 10^{-0.4 \cdot m_{AB}}$

$f_{\nu_S} = 3540\ Jy \cdot 10^{-0.4 \cdot 22} = 5.61 \times 10^{-6}\ \cancel{Jy} \cdot 10^{-26}\ W m^{-2} Hz^{-1}\ \cancel{Jy^{-1}}$

$= 5.61 \times 10^{-32} \frac{W}{m^2 Hz} = 5.61 \times 10^{-29} \frac{erg}{s\ m^2 Hz}$

$f_\lambda = \frac{c}{\lambda^2} f_\nu = \frac{3 \times 10^{18}\ \cancel{Å}/s}{(5600\ Å)^2}\ 5.61 \times 10^{-29} \frac{erg}{s\ cm^2 Hz} = 5.36 \times 10^{-18} \frac{erg}{s\ cm^2\ Å}$

$f_\lambda = 5.36 \times 10^{-18} \frac{erg}{s\ cm^2\ Å} \cdot \frac{5600\ \cancel{Å}}{6.626 \times 10^{-27}\ erg \cdot s \cdot 3 \times 10^{18}\ \cancel{Å/s}} = 1.51 \times 10^{-6} \frac{ph}{s\ cm^2\ Å}$

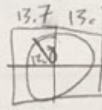
$f = 2.1 \cdot 2.3\ m = 4.83\ m = 4.83 \times 10^6\ \mu m$

$Plt_{sc} = \frac{206265}{4.83 \times 10^6\ \mu m} = 4.27 \times 10^{-2} \frac{''}{\mu m}$

$S_{rad} = \frac{1.1''/2}{4.27 \times 10^{-2}\ ''/\mu m} = 12.8\ \mu m$

this source will have radius ≈ pixel size so can be Nyquist sampled + fit on 4 pixels

13.7 13.7



$FOV = \left(1.1''/2\right) \cdot 2\ pix = 1.1''$

$FOV = 1.21\ \square''$

5) cont. $\eta_{total} = Q \cdot \eta_{atmo} \cdot \eta_{tel}$

$\eta_{atmo} = [2.5^{X \cdot k}]^{-1}$ $k = 0.2 \frac{mag}{airmass}$ $X = 1$ airmass

$\eta_{atmo} = 0.83$

$\eta_{total} = 0.90 \cdot 0.83 \cdot 0.70 = 0.52$

Background:

$\mu_{full} = m + 2.5\log\theta$ $m_{full} = \mu_{full} - 2.5\log(FOV)$

$m_{full} = 20 \frac{mag}{\square''} - 2.5\log(1.21 \square'') = 19.8$ mag

$m_{new} = 22 \frac{mag}{\square''} - 2.5\log(1.21\square'') = 21.8$ mag

not sure how this unit change happens

$f_{\nu_{full/new}} = 3540\,Jy \cdot 10^{-0.4 m_{full/new}} = \begin{matrix} 4.25 \times 10^{-5} Jy \\ 6.75 \times 10^{-6} Jy \end{matrix} \cdot 10^{-26} W m^{-2} Hz^{-1} Jy^{-1}$

$f_{\nu_{full/new}} = \begin{Bmatrix} 4.25 \times 10^{-31} \\ 6.75 \times 10^{-32} \end{Bmatrix} \frac{W}{m^2 Hz} = \begin{Bmatrix} 4.25 \times 10^{-28} \\ 6.75 \times 10^{-29} \end{Bmatrix} \frac{erg}{s\, cm^2 Hz}$

$f_{\lambda_{full/new}} = \frac{3 \times 10^{18} Å/s}{(5600Å)^2} \cdot \begin{Bmatrix} 4.25 \times 10^{-28} \\ 6.75 \times 10^{-29} \end{Bmatrix} \frac{erg}{s\, cm^2 Hz} = \begin{Bmatrix} 4.07 \times 10^{-17} \\ 6.46 \times 10^{-18} \end{Bmatrix} \frac{erg}{s\, cm^2 Å}$

$f_{\lambda_{full/new}} = \begin{Bmatrix} 4.07 \times 10^{-17} \\ 6.46 \times 10^{-18} \end{Bmatrix} \frac{erg}{s\, cm^2 Å} \cdot \frac{5600Å}{6.626 \times 10^{-27} erg \cdot s \cdot 3 \times 10^{18} Å/s} = \begin{Bmatrix} 1.15 \times 10^{-5} \\ 1.81 \times 10^{-6} \end{Bmatrix} \frac{Ph}{s\, cm^2 Å}$

$R = \eta_{tot} \cdot \Delta\lambda \cdot A \cdot f_\lambda$ $A = \pi\left(\frac{2.3m}{2}\right)^2$

$R_{B_{full/new}} = 0.52 \cdot 880Å \cdot \pi\left(\frac{2.3 \times 10^2 cm}{2}\right)^2 \cdot \begin{Bmatrix} 1.15 \times 10^{-5} \\ 1.81 \times 10^{-6} \end{Bmatrix} \frac{Ph}{s\, cm^2 Å}$

$R_{B_{full/new}} = \begin{Bmatrix} 218 \\ 34.4 \end{Bmatrix} \frac{Ph}{s}$

$R_s = 0.52 \cdot 880Å \cdot \pi\left(\frac{2.3 \times 10^2 cm}{2}\right)^2 \cdot 1.51 \times 10^{-6} \frac{Ph}{s\, cm^2 Å}$

$= 28.7 \frac{Ph}{s}$

$$t = \frac{[R_s + n_{px}R_B + n_{px}R_D] \pm \sqrt{[R_s + n_{px}R_B + n_{px}R_D]^2 + 4\left[\frac{R_s^2}{(S/N)}\right] n_{px} N_R^2}}{2 \cdot [R_s^2/(S/N)]}$$

$N_R = 4.5 \frac{e^-}{px}$ $R_{B_{full}} = 218 \frac{Ph}{s}$ $R_D = \emptyset$ $n_{px} = 4$ $S/N = 100$

$t_{full} = 109$ sec $t_{new} = 20.6$ Sec Background limited

2) $\mu = \frac{1 MJy}{sr}$ @ $\lambda = 5500 Å$ V filt $d = 2.3 m$

1 pixel $R_s = ?$

$f_\nu = \mu \cdot px$ $1 px = 1 □''$

$= \frac{1 MJy}{sr} \cdot 1 □'' \cdot \frac{sr}{4.25 \times 10^{10} □''} = 2.35 \times 10^{-11} MJy$

$= 2.35 \times 10^{-5} Jy$

$= 2.35 \times 10^{-31} \frac{W}{m^2 Hz} = 2.35 \times 10^{-28} \frac{erg}{s\, cm^2 Hz}$

$f_\lambda = 2.35 \times 10^{-28} \frac{erg}{s\, cm^2 Hz} \cdot \frac{3 \times 10^{18} Å/s}{(5500 Å)^2} = 2.33 \times 10^{-17} \frac{erg}{s\, cm^2 Å}$

$f_\lambda = 2.33 \times 10^{-17} \frac{erg}{s\, cm^2 Å} \cdot \frac{5500 Å}{6.626 \times 10^{-27} erg \cdot s \cdot 3 \times 10^{18} Å/s} = 6.44 \times 10^{-6} \frac{ph}{s\, cm^2 Å}$

$R_s = \eta_{total} \cdot \Delta\lambda \cdot A \cdot f_\lambda$

$\Delta\lambda = 880 Å$ $A = \pi \left(\frac{2.3 \times 10^2 cm}{2} \right)^2$ $\eta_{tot} = 1.0$

$R_s = 235 \frac{ph}{s}$ per pixel!! → unsure about atmo contrib.

if @ $X = 1$

then $\eta_{tot} = [2.5^{-0.2}] \Longrightarrow 196 \frac{ph}{s}$

3) $d_{src} = 10 Mpc$ $L = 1038 \frac{erg}{s Å}$ in V filt $d_{tel} = 2.3 m$

$\eta_{opt} = 0.5 \cdot \eta_{atmo} = [2.5^{2 \cdot 0.2}]^{-1} = \eta_{tot} = 0.35$

$F = \frac{L}{4\pi r^2} = \frac{1038 \; erg/sÅ}{4\pi \cdot \left(10 \times 10^6 pc \cdot \frac{3.086 \times 10^{18} cm}{pc}\right)^2} = 8.67 \times 10^{-50} \frac{erg}{cm^2 \cdot s \cdot Å}$

$R_s = \eta_{tot} \cdot \Delta\lambda \cdot A \cdot \overbrace{f_\lambda}^{\frac{ph}{s\, cm^2 Å}}$

$= 0.35 \cdot 880 Å \cdot \pi \left(\frac{2.3 \times 10^2 cm}{2} \right)^2 \cdot 8.67 \times 10^{-50} \frac{erg}{s\, cm^2 Å} \cdot \frac{5600 Å}{6.626 \times 10^{-27} erg \cdot s \cdot 3 \times 10^{18} \frac{Å}{s}}$

$= 3.12 \times 10^{-31} \frac{ph}{s}$ NONE!!

4) $R_s = 0.2 \frac{Ph}{s}$ $R_B = 0.5 \frac{Ph}{s}$ $R_D = \frac{10e^-}{hr\ Px}$ $N_R = 5e^-$

$n_{pix} = 4$ # of 1 min exp for $S/N = 100$

$R_d = \frac{10e^-}{\cancel{hr}\ Px} \cdot \frac{\cancel{hr}}{3600s} = \frac{2.7\times10^{-3}\ e^-}{s\ Px}$

$$\frac{S}{N_{min}} = \frac{R_s \cdot t}{\sqrt{R_s t + n_{px}(R_B t + R_D t + N_R^2)}} \Longrightarrow 0.78$$

$t = 60s$ $n_{px} = 4$

$\left(\frac{S}{N}\right)_{min} = 0.78$ $\left(\frac{S}{N}\right)_{tot} = 100 \rightarrow$ # obs $= \frac{(S/N)_{tot}}{(S/N)_{min}} \Rightarrow \frac{100}{0.78} = 128.21$

128.21 observations
w/ rounding $\rightarrow$ 129 obs

not sure this works

6) $QE_K = 0.80$ $\frac{S}{N} = 50$ $t_K = 10\cancel{min} \cdot \frac{60s}{\cancel{min}}$ $\Delta\lambda = 50Å$

$t_W = ?$ using WIRO : $QE_W = 0.95$ V filt Source noise lim

$\frac{S}{N} = \sqrt{R_s t} \rightarrow R_s = t(S/N)^2$

$R_s = \eta_{tot} \cdot \Delta\lambda \cdot A \cdot f_\lambda$ assuming $d_{keck} = 10m$

$\eta_{tot\ keck} = QE_{keck}$

$$f_\lambda = \frac{t_K (S/N)^2}{QE_K \cdot \Delta\lambda \cdot A} \Longrightarrow f_\lambda = 4.77\times10^{-2} \frac{ph}{s\ cm^2\ Å}$$

QE_K: 0.80, $\Delta\lambda$: 50Å, A: $\pi\left(\frac{10\times10^2 cm}{2}\right)^2$

$\left(\frac{S}{N}\right) = \sqrt{R_s t} \rightarrow t = \frac{(S/N)^2}{R_s}$

$R_s = \eta_{tot} \cdot A \cdot \Delta\lambda \cdot f_\lambda = 1.65\times10^6 \frac{ph}{s}$

η_{tot}: $QE_W = 0.95$, A: $\pi\left(\frac{2.3\times10^2 cm}{2}\right)^2$, $\Delta\lambda$: 880Å for V band

$t = \frac{50^2}{1.65\times10^6 ph/s} \Rightarrow 1.51\times10^{-3}\ s$ This is faster than shutter??

1) for V band: $m_1 = 10$ $m_2 = 10.03$

$f_{\nu 1} = 3540 Jy \cdot 10^{-0.4 \cdot 10} \Rightarrow 0.354\ Jy$ 1% of $\rightarrow 3.54\times10^{-3} Jy$

$f_{\nu 2} = 3540 Jy \cdot 10^{-0.4 \cdot 10.03} \Rightarrow -0.344\ Jy$ $\times 3 \Rightarrow 0.0106 Jy$

$0.01\ Jy$ $3\% = 0.01\ Jy$

!!! 3% flux = 0.03 magnitude