HW3

Q4.

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

$$100 = \frac{0.2\,ph\,s^{-1} \cdot t}{\sqrt{0.2\,ph\,s^{-1} \cdot t + 4(0.5\,ph\,s^{-1}\,pix^{-1} \cdot t + 0.0027\,e\,s^{-1}\,pix^{-1} \cdot t + 25)}}$$

$\Rightarrow$ $t = 552{,}745$ seconds

$= 9212.4$ min

$\Rightarrow$ 9213 1-min exposures

Q1. $F_2 = 1.03 F_1$ (or $0.97 F_1$)

$$m_2 - m_1 = -2.5 \log\left(\frac{F_2}{F_1}\right) = -2.5 \log(1.03)$$

or 0.97

$m_1 + \text{error} - m_1 = \pm 0.032$

$\Rightarrow$ error $= \pm 0.032$ magnitudes

Q2. from HW2,

$f_\nu = 6.45 \times 10^{-6}\ ph\ s^{-1}\ cm^{-2}\ Å^{-1}\ arcsec^{-2}$

$1\ pix = 1\ arcsec^2$

efficiency = 100%

$\Delta\lambda$ = bandwidth = 893.10 Å

area $= \pi r^2 = 4.15\ m^2 = 4.15 \times 10^4\ cm^2$

$$ph\ s^{-1}\ pix^{-1} = 6.45 \times 10^{-6}\ ph\ s^{-1}\ cm^{-2}\ Å^{-1}\ arcsec^{-2} \times \frac{1\ arcsec^2}{1\ pix} \times 893.10\ Å \times 4.15 \times 10^4\ cm^2$$

$R = 239.06$ photons $s^{-1}\ pix^{-1}$

Q3. $R = QE \cdot n_{atmos} \cdot \Delta\lambda \cdot A \cdot f_\lambda$ ($QE \to 0.5$, $\Delta\lambda \to 893.1\,\text{Å}$)

> Brayan said this might have been 10^{38} ..... if so, answer becomes $R = 2.97\times10^{4}$ ph s^{-1}

$A = 4.15\times10^{4}\ \text{cm}^2$

$$f_\lambda = \frac{L}{4\pi d^2} = \frac{10^{38}\ \text{erg s}^{-1}\ \text{Å}^{-1}}{4\pi(10\,\text{Mpc})^2}$$

$$= 8.674\times10^{-50}\ \text{erg cm}^{-2}\ \text{s}^{-1}\ \text{Å}^{-1}$$

$$1\ \text{ph} = \frac{hc}{5500\,\text{Å}} = 3.612\times10^{-12}\ \text{erg}$$

$f_\lambda = 2.4\times10^{-38}\ \text{ph cm}^{-2}\ \text{s}^{-1}\ \text{Å}^{-1}$

$n_{atmos} = [2.5^{x\cdot k}]^{-1}$ airmass = 2

$= 0.693$ V-band extinction coefficient = 0.2

$\Rightarrow R = 3.08\times10^{-31}$ ph s^{-1}

Q5. seeing = 1.1'' ~~→ we want 0.55''~~

$R = f/d \to f = 2.3\times2.1 = 4.83\,\text{m} = 4.83\times10^{6}\,\mu\text{m}$

$$\text{platescale} = \frac{206265}{4.83\times10^{6}\,\mu\text{m}} = 0.043''/\mu\text{m}$$

$\cancel{\frac{0.55''}{0.043''/\mu\text{m}} = 12.88\,\mu\text{m}}$

$1\ \text{pix} = 13.5\,\mu\text{m}$

$1\ \text{pix} = 13.5\,\mu\text{m}\times0.043''/\mu\text{m} = 0.58''$

FWHM = 1.89 ≃ 2 pix

$n_{pix} = 4$ pix

$ZP_{\lambda,V} = 3.58\times10^{-9}\ \text{erg cm}^{-2}\ \text{s}^{-1}\ \text{Å}^{-1}$

$f_{\lambda,s} = ZP\times10^{-0.4\times22}$

$= 5.67\times10^{-18}\ \text{erg cm}^{-2}\ \text{s}^{-1}\ \text{Å}^{-1}$

full moon: $f_{\lambda,B} = ZP\times10^{-0.4\times20} = 3.58\times10^{-17}\ \text{erg cm}^{-2}\ \text{s}^{-1}\ \text{Å}^{-1}\ \text{arcsec}^{-2}$

new moon: $f_{\lambda,B} = 5.67\times10^{-18}\ \text{erg cm}^{-2}\ \text{s}^{-1}\ \text{Å}^{-1}\ \text{arcsec}^{-2}$

$$R_S = 0.9 \times 0.7 \times 893.1\,\text{Å} \times 4.15\times10^{4}\,\text{cm}^2 \times \frac{5.67\times10^{-18}\,\text{erg cm}^{-2}\text{s}^{-1}\text{Å}^{-1}}{3.612\times10^{-12}\,\text{erg/ph}}$$

$$= 36.654\ \text{ph s}^{-1}$$

$$R_{B,\text{full moon}} = 231.43\ \text{ph s}^{-1}\ \text{arcsec}^{-2}$$

$$1\,\text{pix} = (13.5\,\mu\text{m} \cdot 0.043\,''/\mu\text{m})^2$$
$$= 0.337\ \text{arcsec}^2$$

$$R_{B,\text{full moon}} = 77.99\ \text{ph s}^{-1}\ \text{pix}^{-1}$$

~~we only have 1 pix so we can just use this number~~

$$R_{B,\text{new moon}} = 36.654\ \text{ph s}^{-1}\ \text{arcsec}^{-2}$$
$$= 12.35\ \text{ph s}^{-1}\ \text{pix}^{-1}$$

$N_R^2 = 4.5$ e/pix

$R_D = 0$

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

$$100 = \frac{R_S \cdot t}{\sqrt{R_S \cdot t + (R_B \cdot t + N_R^2)\,n_{pix}}}$$

full moon:

$$\Rightarrow t = \overset{2594.84}{\cancel{853.35}}\ \text{seconds} = \overset{43.25}{\cancel{14.2}}\ \text{mins}$$

new moon:

$$\Rightarrow t = \overset{640.72}{\cancel{364.83}}\ \text{seconds} = \overset{10.68}{\cancel{6.08}}\ \text{mins}$$

we are background limited.

Q6. $S/N = \sqrt{R_s \cdot t}$

$= \sqrt{t \cdot QE \cdot \Delta\lambda \cdot A \cdot f}$

Keck S/N = WIRO S/N

$\sqrt{10\,\text{min} \cdot 0.8 \cdot 50\,\text{Å} \cdot 7.85\times10^{5}\,\text{cm}^2 \cdot f} = \sqrt{t \cdot 0.95 \cdot 893.1\,\text{Å} \cdot 4.15\times10^{4}\,\text{cm}^2 \cdot f}$

$\Rightarrow t = 535$ seconds

$= 8.9$ mins

assuming:

telescopes at same location → same airmass, alt, etc...

observing at the same time → same seeing, weather, moon phase, etc.