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HW 3 Sebastian

~~Sf~~ 1)

$$m_i = -2.5 \log_{10}\left(\frac{\mathcal{F}_i}{zp_i}\right)$$

if $\mathcal{F}_i$ has error $d\mathcal{F}_i = 0.03\mathcal{F}_i$

$$dm_i = -\frac{2.5}{\ln(10)} \cdot \frac{d\mathcal{F}_i}{\mathcal{F}_i} = +1.0857 \cdot 0.03$$

$$\boxed{= 0.033 \text{ mag}}$$

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

$f_\nu / str = 1 \cdot 10^{-17} \, erg\, s^{-1} cm^{-2} Hz^{-1} \cdot str^{-1}$

$f_\nu / \square'' = 2.35 \cdot 10^{-28} \, erg\, s^{-1} cm^{-2} Hz^{-1} \square''^{-1} \rightarrow$ we want f_ν over $1\square''$, so f_ν is equal to this value

$$f_\lambda = f_\nu \frac{\delta\nu}{\delta\lambda} = f_\nu \frac{3 \cdot 10^{18} \text{Å}/s}{(5500\text{Å})^2} = 2.33 \cdot 10^{-17} \, erg\, s^{-1} cm^{-2} \text{Å}^{-1}$$

~~R~~ $1ph = \frac{6.626 \cdot 10^{-27} \, erg \cdot s \cdot 3 \cdot 10^{18} \text{Å}/s}{5500 \text{Å}} \, erg$

$= 3.61 \cdot 10^{-12} \, erg$

$f_\lambda = 6.46 \cdot 10^{-6} \, ph\, s^{-1} cm^{-2} \text{Å}^{-1}$

$$R = (100\%)\underbrace{(900\text{Å})}_{\Delta\lambda_V}\underbrace{(41547 \, cm^2)}_{A = \pi\left(\frac{2.3}{2} \cdot 100\right)^2} \cdot 6.46 \cdot 10^{-6} \, ph\, s^{-1} cm^{-2} \text{Å}^{-1}$$

$$\boxed{= 241.55 \, ph\, s^{-1}}$$

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3) $d = 10$ Mpc , $L_\lambda = 10^{38}$ erg s^{-1} Å^{-1} over optical @ $z = 2$

$$f_\lambda = \frac{L_\lambda}{4\pi d^2} = 8.36 \cdot 10^{-15} \text{ erg s}^{-1}\text{cm}^{-2}\text{Å}^{-1}$$

$$f_\lambda = 2.32 \cdot 10^{-3} \text{ ph s}^{-1}\text{cm}^{-2}\text{Å}^{-1}$$ (using 5500 Å photon)

$$\eta = 0.50 \cdot 2.5^{-2 \cdot 0.2} \cancel{= 0.69} = 0.35$$

~~$R = (0.69)$~~

$$R = (0.35)(900 \text{ Å})(41547 \text{ cm}^2) \cdot 2.32 \cdot 10^{-3} \text{ ph s}^{-1}\text{cm}^{-2}\text{Å}^{-1}$$

$$\boxed{R_s = 30362.55 \text{ ph s}^{-1}}$$

4) $R_s = 0.2$ ph s^{-1}, $R_B = 0.5$ ph s^{-1} pix^{-1}

$R_D = 10 e^- \text{ hr}^{-1} \text{ pix}^{-1}$, $N_R^2 = 5$, $n_{pix} = 4$

$= 0.0028 e^- s^{-1} \text{pix}^{-1}$

$$\frac{S}{N} = \frac{R_s t}{\sqrt{R_s t + n_{pix}(R_B t + R_D t + N_R^2)}} \overset{!}{=} 100$$

$\hookrightarrow t = 552,792$ s

$\hookrightarrow 9213.2$ or

9214, 60 s exposures

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5] $d = 2.3\,m$, $f/2.1$, $pix = 13.5\,\mu m$

$$s = \frac{206265''}{d \cdot f\,(\mu m)} = 0.0427''/\mu m = 0.57645''/pix$$

$$\text{seeing} = 1.1'' \rightarrow \frac{1.1''}{0.57645''/pix} = 1.908\,pix \approx 2\,pix$$

(4 pix total)

$m_v = 22\,mag$

$$\hookrightarrow f_\nu = 3640 \cdot 10^{-0.4 \cdot 22} = 5.77 \cdot 10^{-29}\,erg\,s^{-1}\,cm^{-2}\,Hz^{-1}$$

$$f_\lambda = 5.72 \cdot 10^{-18}\,erg\,s^{-1}\,cm^{-2}\,Å^{-1}$$

$$= 1.58 \cdot 10^{-6}\,ph\,s^{-1}\,cm^{-2}\,Å^{-1}$$

$$\text{So } R_s = \underbrace{(\eta_{total})}_{0.9 \cdot 0.7 \cdot 0.7 \cdot 2.5^{-0.8}}\left(\pi\left(\frac{2.3}{2} \cdot 100\right)^2\right)(900)\,f_\lambda$$

$$\boxed{= 21.68\,ph\,s^{-1}}$$

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Same process but w/ $f_{\nu_B} = 3640 \cdot 10^{-0.4 \cdot 20} \ldots$

$\mu_v = 20$ background:

$$f_\lambda = 9.99 \cdot 10^{-6}\,ph\,s^{-1}\,cm^{-2}\,Å^{-1}\,\square''^{-1}$$

2 pix by 2 pix
$1.1529'' \times 1.1529'' = 1.329\,\square''$

$$\boxed{R_B^* = 137.08\,ph\,s^{-1}\,\square''^{-1}} \rightarrow \boxed{R_B = 182.2\,ph\,s^{-1}}$$

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$\mu_V = 22$

background : Same process, same flux but over $1.329\ \square''$, so

$$\boxed{R_B = 28.82\ \text{ph s}^{-1}}$$

$N_B^2 = 4.5\ e^-\ \text{pix}^{-1}$

$$\frac{S}{N} = \frac{R_S t}{\sqrt{R_S t + n_{pix}(R_B t + N_B^2)}} \overset{!}{=} 100 \Rightarrow t = 15{,}966\ \text{s}$$

when moon is full

$t = 2914$ s

when moon is new

~~My detector is background~~ We are background limited in this case

G) $\cancel{50 = \sqrt{R_S t}}$ $\frac{S}{N} = \sqrt{R_S t}$ for source limited case

$$R_S = A \cdot \Delta\lambda \cdot Q\,\varepsilon \cdot f_\lambda$$

$t = 10\ \text{min} \rightarrow 8.85\ \text{min}$ for $S/N = 50$

So
$$\frac{R_{S\,WIRO}}{R_{S\,keck}} = \frac{\pi(1.15)^2 \cdot 900 \cdot 0.95 \cdot \cancel{f_\lambda}}{\pi(5)^2 \cdot 80 \cdot 0.80 \cdot \cancel{f_\lambda}} = 1.13$$

So R_S increases by a factor of $1.13 \Rightarrow$ we need $1.13\times$ LESS time

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