ASTR 414 HW 4

February 19, 2018

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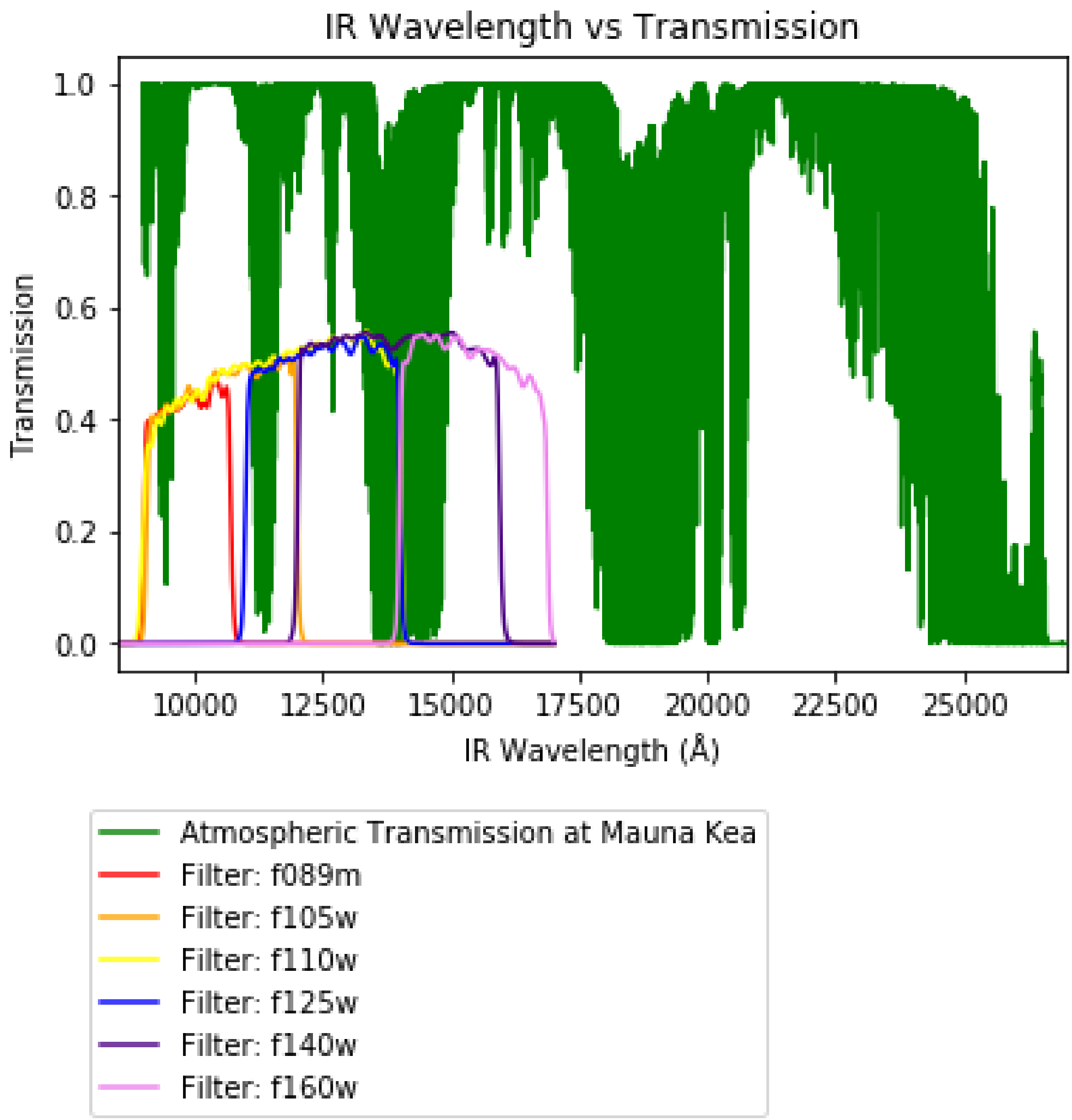
Problem 1:



Problem 2:

6:

aperture = 0.1 meters
focal ratio = f/60
CCD is 1024 x 1024 and each pixel is 18 μm^2

Focal length (f) = Focal ratio $*$ Aperture:

$$f = 6 * 1m$$

$$f = 6m$$

Frame width = Image Scale $*$ CCD length
Image Scale:

$$s = \frac{206265 \text{ arcsec}}{f}$$

$$s = \frac{206265 \text{ arcsec}}{6m}$$

$$s = 343377.5"m$$

Frame Width:

$$\text{Pixel Scale} = 343377.5\frac{arcsec}{m} * \frac{1m}{1x10^6 \mu m} * \sqrt{18\mu m^2}$$

$$\boxed{\text{Pixel Scale} = 0.145\frac{arcsec}{pixel}}$$

$$\text{Frame Width} = 0.145\frac{arcsec}{pixel} * 1024 \text{ pixels} * \frac{1arcmin}{60arcsec}$$

$$\boxed{\text{Frame Width} = 2.489 \text{ arcmin}}$$

8:

δ_{Mars} = 15 arcsec
F = 1.0 x $10^{-7} Wm^{-2}$
Pixel Length (ℓ) = 25 $\mu m = 2.5x10^{-5}m$
Albert: D_a = 0.3m, f/8 Bertha: D_b = 30m, f/4 t = 100s
Focal Length:

$$\text{focal ratio} = D$$

$$f_A = 0.3m * 8 = 2.4m$$

$$f_B = 30m * 4 = 120m$$

Image Scale:

$$s = \frac{206256 \text{ arcsec}}{f}$$

$$s_A = \frac{1}{2.4m} = 8.59x10^4 \frac{arcsec}{m^{-1}}$$
$$s_B = \frac{1}{120m} = 1.718x10^3 \frac{arcsec}{m^{-1}}$$

Pixel Scale:

$$s_{pix,A} = s_A * \ell = 8.59x10^4 \frac{arcsec}{m^{-1}} * 2.5x10^{-5} m = 2.14 \frac{arcsec}{pixel}$$
$$s_{pix,B} = s_B * \ell = 1.718x10^3 \frac{arcsec}{m^{-1}} * 2.5x10^{-5} m = 4.29x10^{-2} \frac{arcsec}{pixel}$$

Inverse of the Angular Diameter of Mars in pixels for each telescope:

$$\delta^{-1}_{Mars,A,pix} = \frac{S_{pix,A}}{\delta_{Mars}} = \frac{2.14 \frac{\text{arcsec}}{\text{pixel}}}{15 \text{ arcsec}} = 0.143 \text{ pixels}^{-1}$$

$$\delta^{-1}_{Mars,B,pix} = \frac{S_{pix,B}}{\delta_{Mars}} = \frac{4.29x10^{-2} \frac{\text{arcsec}}{\text{pixel}}}{15 \text{ arcsec}} = 2.86x10^{-3} \text{ pixels}^{-1}$$

Energy:

$$E = \delta^{-1}_{pix} * t * flux * A_{\text{pixel}}$$

$$E_{Albert} = 0.143 \text{ pixels}^{-1} * 100s * 10^{-7} \frac{W}{m^2} * (2.5x10^{-5})^2 m^2 = \boxed{8.96x10^{-16} \frac{\text{J}}{\text{pixel}}}$$

$$E_{Bertha} = 2.86x10^{-3} \text{pixels}^{-1} * 100s * 10^{-7} \frac{W}{m^2} * (2.5x10^{-5})^2 m^2 = \boxed{1.79x10^{-17} \frac{\text{J}}{\text{pixel}}}$$

9:

$D_{HST} = 2.4m$
$D_{ST} = 8m$
UV $= 300nm = 3x10^{-7} m$
NIR $= 2.0\mu m = 2x10^{-6} m$

$$\theta = \frac{1.22 * \lambda}{D}$$
$$\theta_{UV,HST} = \frac{1.22 * UV}{D_H ST}$$
$$\theta_{UV,HST} = \frac{1.22 * 3x10^{-7} m}{2.4m}$$
$$\boxed{\theta_{UV,HST} = 1.525x10^{-7} \text{ rad}}$$

$$\theta_{NIR,HST} = \frac{1.22 * 2x10^{-6}}{2.4m}$$

$$\boxed{\theta_{NIR,HST} = 1.017x10^{-6} \text{ rad}}$$

$$\theta_{NIR,ST} = \frac{1.22 * 3x10^{-7}m}{8m}$$

$$\boxed{\theta_{NIR,ST} = 3.05x10^{-7} \text{ rad}}$$

The Hubble Space Telescope is has a larger diffraction limit than the telescope with a diameter of 8m. This shows that the telescope with the larger diameter is able to resolve smaller angles.

Problem 3:

9:

$D_{HST} = 2.4m$
$D_{JWST} = 6.5m$
$m_{HST} = 26.0$

From page 136 of Chromey:

$$f_{d,space} = (\frac{hc\lambda}{Q})^{\frac{1}{2}}(\frac{b_\lambda}{t})^{\frac{1}{2}}\frac{2.44}{D^2}$$

Since h, c, λ, Q, and t are the same for both telescopes, the ratio of the fluxes can be manipulated to the following, as well as using the relation that 1 magnitude = 2.512 $\frac{\text{magnitudes}}{\text{arcsec}^2}$ of brightness:

$$\frac{f_{HST}}{f_{JWST}} = \frac{D^2_{JWST}}{D^2_{HST}}(\frac{b_{\lambda,HST}}{b_{\lambda,JWST}})^{\frac{1}{2}} = \frac{D^2_{JWST}}{D^2_{HST}}(\frac{\sqrt{b_{\lambda,HST}}}{\sqrt{2.512 * b_{\lambda,HST}}})$$

$$\frac{f_{HST}}{f_{JWST}} = \frac{(6.5m)^2}{(2.4m)^2 * \sqrt{2.512}} = 4.628$$

$$m_{HST} - m_{JWST} = 2.5log_{10}(\frac{f_{HST}}{f_{JWST}})$$

$$m_{JWST} = 2.5log_{10}(4.628^2) + 26.0$$

$$\boxed{m_{JWST} = 29.33}$$