Astrophotography Basics

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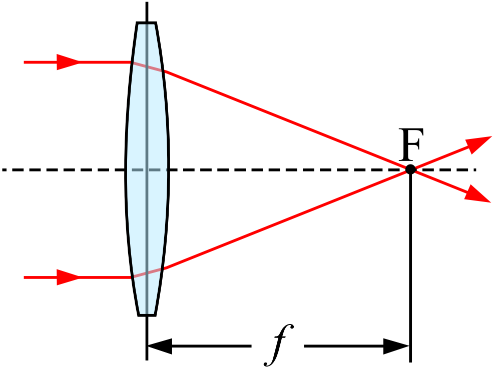
Exposure Time, F-Stop, ISO. . .

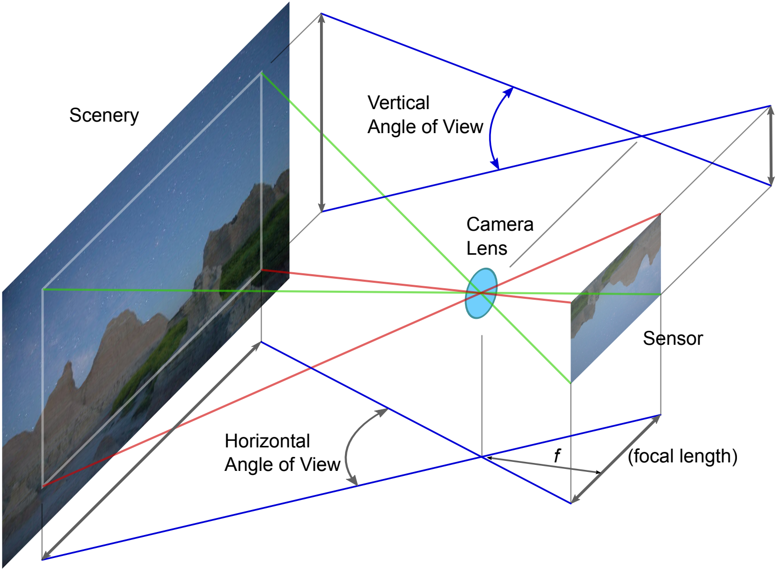
Imaging — From Scenery to Camera



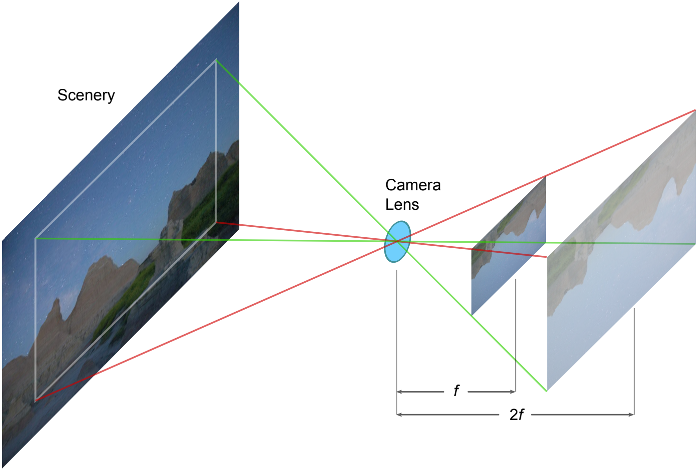
F: focal point

f: focal length

Imaging — From Scenery to Camera II



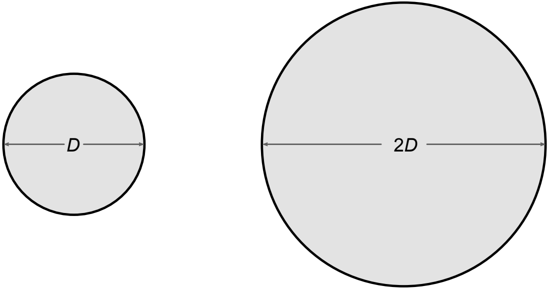
Effect of Focal Length



Double f $\longrightarrow$ quadruple area (same light spread over $4\times$ the area)

Therefore: Light intensity $\propto \frac{1}{f^2}$

Effect of Iris Diameter



Double $D \longrightarrow$ sensor receives 4 times as much light
Therefore: Light intensity $\propto D^2$

Focal Ratio

- From the previous two slides:

  light intensity on sensor proportional to $\frac{D^2}{f^2} = \left(\frac{D}{f}\right)^2 = \frac{1}{\left(\frac{f}{D}\right)^2}$

- Example: $f = 80$ mm, $D = 20$ mm $\quad \rightarrow \quad \frac{f}{D} = \frac{80}{20} = 4$

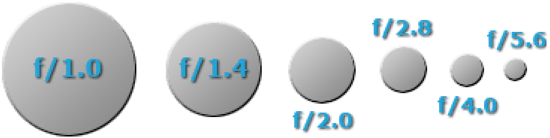
- Now reduce D from 20 to 10 mm: $\frac{f}{D} = \frac{80}{10} = 8$

  This will cut the light intensity by a factor of 4.

- By how much would we need to change f/D to reduce the light intensity by a factor of 2:

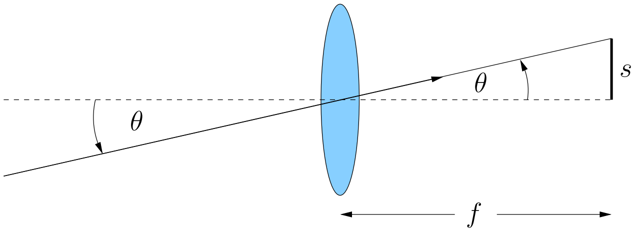
  Answer: by $\sqrt{2} = 1.414\ldots$, i.e. $4 \times \sqrt{2} = 5.6$

Focal Ratio (cont'd)



- So, light intensity doubles/halves if f/D is varied by factors of $\sqrt{2}$:
  1 1.4 2 2.8 4 5.6 8 11 16 ...
- These are the standard *focal ratios* or *f-stop numbers* on your camera
- Smaller numbers → **more** light

Image size



- size on sensor: $s = f \times \tan\theta$

- For small angles θ (5° or less):

$$
\begin{aligned}
s &= f \times \frac{\theta}{57} && \text{angle in degrees} \\
&= f \times \frac{\theta}{3400} && \text{angle in arcminutes} \\
&= f \times \frac{\theta}{205{,}000} && \text{angle in arcseconds}
\end{aligned}
$$

Image size (cont'd)

- Example 1: Moon (diameter 0.5°) with 200 mm telephoto lens

$$s = 200\,\text{mm} \times \frac{0.5}{57} = 1.8\,\text{mm}$$

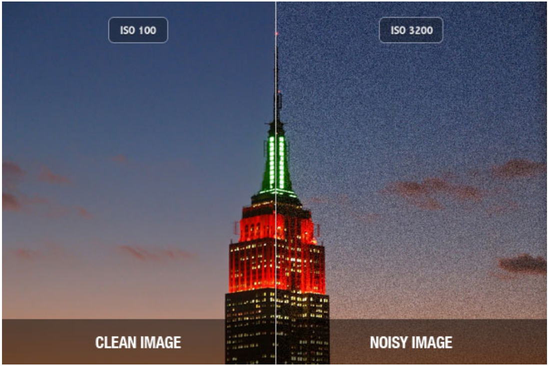
- Compare with typical APS sensor size (22 mm × 14 mm): Tiny!

- Example 2: Jupiter (diameter 48″); want 5 mm size on sensor

$$f = 5\,\text{mm} \times \frac{205{,}000}{48} = 21\,\text{m}$$

- Need eyepiece projection!

ISO: Sensor Sensitivity



- “Normal” sensitivity: ISO 100
- Modern DSLRs: 25,600 and up
- Beware: higher ISO $\rightarrow$ more noise!