ASTR3010 — 08/17
Calculating FOV: Review

→ we can use the following formula to compute the <u>true</u> field of view:

$$\text{field of view} = \frac{\text{apparent field of view}}{\text{magnification}}$$ } usually provided by manufacturer

- apparent FOV:
  ↳ eyepieces have apparent FOVs: number of degrees of sky your eyepiece would show if held directly up to sky.
  → not always specified!
  → a decent assumption for cheap scopes is 50°.

- true field of view:
  ↳ number of degrees visible when eyepiece is used with telescope.
  → given by dividing A_{FOV} by the magnification the eyepiece provides when used with the telescope.

- magnification:
  ↳ recall: we can compute the combined eyepiece—telescope magnification as follows —

$$m_{net} = \frac{\text{focal length of telescope}}{\text{focal length of eyepiece}}$$

→ we can alternatively use a different formula:

$$\text{field of view} = 2 \cdot \arctan\left(\frac{r}{f_{telescope}}\right)$$

} r = radius of field stop/aperture of eyepiece
f_t = telescope focal length

→ equipment information:

- Celestron Firstscope
  ↳ $f_{telescope} = 300\text{mm}$
  → highest mag = 180x
  → lowest mag = 11x

- Eyepiece 1
  ↳ $f_{e1} = 20\text{mm}$
  → $mag_{e1} = 15\text{x}$
  → AFOV = 52°

- Eyepiece 2
  ↳ $f_{e2} = 4\text{mm}$
  → $mag_{e2} = 75\text{x}$
  → AFOV = 50°

- Wide Angle Eyepiece
  ↳ $f_W = 23\text{mm}$
  → A FOV = 62°

→ FOV of telescope & eyepiece 1:

$$m_{net} = \frac{f_t}{f_{e1}} = \frac{300mm}{20mm} = 15x$$

$$FOV_{t,e1} = \frac{AFOV_{e1}}{m_{net}} = \frac{52°}{15} = 3.4\overline{6}°$$

with camera:

$m_{net} = 15x$

$$\text{effective AFOV} = \frac{TFOV}{\text{magnification of camera setup}} = 3.4\overline{6}°$$

→ FOV of telescope & eyepiece 2:

$$m_{net} = \frac{f_t}{f_{e2}} = \frac{300mm}{4mm} = 75x$$

$$FOV_{t,e2} = \frac{AFOV_{e2}}{m_{net}} = \frac{50°}{75} = \frac{2}{3} = 0.\overline{6}°$$

$$eAFOV = \frac{0.\overline{6}°}{1} = 0.\overline{6}°$$

→ FOV of telescope & eyepiece 3:

$$m_{net} = \frac{f_t}{f_w} = \frac{300mm}{23mm} = \frac{300}{23} \approx 13x$$

$$FOV_{t,w} = \frac{AFOV_w}{m_{net}} = \frac{62°}{300/23} = \frac{713}{150} = 4.75\overline{3}°$$

$$eAFOV = \frac{4.75\overline{3}°}{1} = 4.75\overline{3}°$$

→ we must also consider how my smartphone camera may affect this process:

- iPhone 14 Pro
  - ↳ $f_{cam} = 24mm$ (main lens has 24mm equivalent focal length)
  - → $mag_{cam} = 1$
  - → 48MP type $1/1.28$ ($9.8 \times 7.3mm$) camera sensor

$\therefore AFOV_{cam} = 28.57°$

- we also need the FOV of the camera:

$$FOV = 2\arctan\left(\frac{H}{2f}\right) \quad \begin{cases} H = \text{horiz. dim. of camera sensor} \\ f = \text{focal length} \end{cases}$$

$$\therefore FOV_{cam} = 2\arctan\left(\frac{\sqrt{9.8^2 + 7.3^2}}{2 \cdot 24}\right) \approx 28.57°$$

→ converting our measurements to arcseconds:

- recall — 1 deg = 3600 arcsec

$\therefore FOV_1 = 3.47° \cdot 3600 \text{ arcsec/degree} \approx 12{,}492''$

$FOV_2 = 0.67° \cdot 3600 \text{ arcsec/degree} \approx 2{,}412''$

$FOV_3 = 4.75° \cdot 3600 \text{ arcsec/degree} \approx 17{,}100''$

→ lastly, we must compute the pixel scaling:

$$\text{pixel scale} = \frac{\text{FOV}}{\text{no. of pixels } \underline{\text{across}} \text{ sensor}} \longrightarrow \text{computed above}$$

↳ 48,000,000 pixels total in a 4:3 default aspect ratio means:

- $\text{horiz. pixels} = \sqrt{\frac{48\,\text{mp} \cdot 4}{3}} \cdot \frac{4}{\sqrt{4^2 + 3^2}} \approx 8064 \text{ pixels}$

$$\therefore \text{pixel scale}_1 = \frac{12{,}492''}{8064\,\text{px}} \approx 1.55 \text{ arcsec/pixel}$$

$$\text{pixel scale}_2 = \frac{2{,}412''}{8064\,\text{px}} \approx 0.30 \text{ arcsec/pixel}$$

$$\text{pixel scale}_3 = \frac{17{,}100''}{8064\,\text{px}} \approx 2.12 \text{ arcsec/pixel}$$