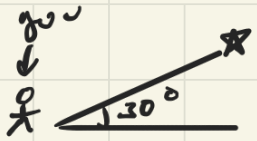
- You observe a star at a 30° elevation!!
- its observed U-band mag is $U = 15$ mag



Q: What is its magnitude corrected for extinction?

- airmass: $X = \frac{1}{\cos\theta} = \frac{1}{\cos 30^\circ} = 1.15$
- magnitude: $m(X) = m_0 + kX$
  - $m(X)$ = measured mag
  - m_0 = mag w/o extinction
  - k = constant (for U-band, $k = 0.6$)
  - X = airmass
- $m_0 = m(X) - kX = 15\,\text{mag} - (0.2)(1.15)$

→ $m_0 = 14.81$ mag

Q: How many photons should strike a CCD in a 10 sec exposure with a 20 in diameter telescope?

- a star of $U = 0$ mag produces 550×10^3 photons/s/cm²

- for 0 mag star:
  - $N_{photons} = I = \left(550 \times 10^3 \frac{\text{photons}}{\text{cm}^2\,\text{s}}\right) A_{telescope}\, t$

→ $N_{photons} = I = \left(550 \times 10^3 \frac{\text{photons}}{\text{cm}^2\,\text{s}}\right)\left(\pi (25.4\,\text{cm})^2\right)(10\,\text{s})$

  - $R = 10\,\text{in} = 25.4\,\text{cm}$

→ $N_{photons} = 1.12 \times 10^{10}$ photons

- ratio of intensities: $\frac{I_{15}}{I_0} = 10^{-0.4(m_{15}-m_0)}$

→ $I_{15} = I_0\, 10^{-0.4(m_{15}-m_0)}$

→ $I_{15} = (1.12\times10^{10}\ \text{photons})\, 10^{-0.4(15-0)}$ = **11200 photons**

- The quantum efficiency of the detector is 70%
  - (1 photon = $0.7e^-$)

Q: How many electrons are detected?

- $Ne^- = (\text{efficiency})(N_{\text{photons}}) = (70\%)(11200\ \text{photons})$

→ **$Ne^- = 7840\ e^-$**

- the average thermal noise is 400 counts/pixel
- The aperture radius is 5
- the # of counts from the sky is 30
- the camera readout is 10 e^- RMS per pixel
- the gain is: $\frac{2.8\ e^-}{\text{count}}$

Q: calculate the SNR using:

- $$SNR = \frac{N_*}{(N_* + (n_{pix} N_b) + (n_{pix} N_{th}) + (n_{pix} R^2))^{1/2}}$$

- N_* = Ne^- from star = $7840\ e^-$ from earlier
- n_{pix} = # pixels in aperature = Area of circle

→ $n_{pix} = \pi R^2 = \pi(5)^2 = 78.54$ pixels

- N_b = background sky:

- $30 \frac{\text{counts}}{\text{pixel}} \cdot \frac{2.8 e^-}{1 \text{ count}} = 84 \frac{e^-}{\text{pixel}}$
- N_{th} = thermal:
  - $400 \frac{\text{counts}}{\text{pix}} \cdot \frac{2.8 e^-}{1 \text{ count}} = 1120 \; e^-/\text{pix}$
- R is the camera readout: $10 \; e^-/\text{pix}$
- plugging everything in:

$$SNR = \frac{7840 e^-}{7840 e^- + (78.54_p)(84 \frac{e^-}{p}) + (78.54_p)(1120 \frac{e^-}{pix}) + (78.54_p)(10 \frac{e^-}{p})^2]^{1/2}}$$

→ **SNR = 23.6**